THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Designing for Resource-Efficient Manual Work Activities at Hospital Care Units

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Abstract

Although Swedish healthcare needs to increase productivity to become able to meet demand projected for the future, public healthcare in Sweden currently shows a downward trend in productivity. The research presented in this licentiate thesis aims to improve the resource efficiency of manual work activities performed in Sweden's hospital care units and, in turn, contribute to increased productivity in the nation's healthcare. In that context, *resource efficiency*, defined in light of production engineering, refers to how efficiently activities are performed by resources in producing output.

The thesis provides answers to three research questions regarding (i) how medication work in hospital care units should be improved to become more efficient; (ii) how work activities in care units should be identified, collected, and organised systematically; and (iii) how resource efficiency can be systematically improved for manual work activities in hospital care units.

The framework of the thesis is based on design science research, and the methods used in the accompanying research included work design and work study analysis. Two projects conducted at Sahlgrenska University Hospital, a large public hospital in Sweden, constitute the empirical basis of the thesis. First, the Standard for Medication Work in Care Units project concerned how to design a solution to change the conditions for performing the work activity of preparing medication more efficiently. Its results include principles for designing medication rooms, configurations for designing work stations and kit storage, and ways to prioritise the placement of furnishings in medication rooms. Second, the Systematic Work Activity Mapping project concerned ways to design a solution for identifying and organising work activities in hospital care units. The results of this project include a systematic work activity mapping method, a systematic work activity mapping structure, a work activity denomination terminology, and a comprehensive list of work activities mapped in nine care units. The evolution of the field problems and design problems, the design of the interventions, the plan for their implementation, and the methods used to design the solutions are also discussed in the thesis.

The chief result of the thesis is the series of four steps necessary to achieve improvements in resource efficiency of work activities as a means to increase productivity in the aggregate: systematic mapping of work activities, conducting a work sampling study, improving work methods, and realising the improvement. Suggestions for further research to contribute to resource efficiency and productivity in Sweden's healthcare system conclude the thesis.

KEYWORDS
Resource efficiency, Work activities, Design science research, Healthcare

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Simon O. Hermansson

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Glossary

This glossary is included to provide explanations terms that are not readily understood when translated from Swedish or a Swedish healthcare context.

Assistant nurse (Swedish: Undersköterska)

Unlicensed assistive nurse personnel who perform basic patient care and assist patients.

Care unit (Swedish: Vårdavdelning)

A ward at a hospital to which inpatients are admitted to stay for treatment and care.

Medication room (Also: Pharmaceutical room) (Swedish: Läkemedelsrum)

Room at a care unit where medications are stored and typically prepared.

Pharmacist (Swedish: Apotekare)

Master of Science in Pharmacy.

Preparer (Swedish: Iordningställare)

Someone that prepares (medications).

Prescriptionist (Swedish: Receptarie)

Bachelor of Science in Pharmacy.

Registered nurse (Swedish: Sjuksköterska)

Licensed nurse registered in the Swedish National Board of Health and Welfare's National Planning Support register.

SVD-medications (Swedish: Slutenvårdsdos)

Delivery of certain medication tablets and caplets in patient specific, adjoined plastic pouches with each pouch containing a different medication. SVD-medications are delivered to care units as a rolls of pre-packaged patient-specific plastic pouches each one containing the patient-specific dose of one medication for one administration period, i.e. each patient could have a number of pouches per administration period for several periods per day.

List of Appended Papers

Paper I

Productivity potentials at hospital wards – The case of pharmaceuticals dispensing

Hermansson and Almström (2016)

Conference paper/Working paper

Presented at the 7th Swedish Production Symposium in Lund, Sweden on October 25-26, 2016 and by Peter Almström as 'Using work studies to dramatically improve performance at hospital wards' at the 23rd EurOMA Conference in Trondheim, Norway on June 19-21, 2016.

Paper II

Towards the activity based hospital

Hermansson and Almström (2018)

Conference paper/Working paper

Presented at the 25th EurOMA Conference in Budapest, Hungary on June 24-26, 2018 and as 'Systematic Mapping of Care Ward Activities – Towards a Standardized Activity Structure and Terminology of Hospital Activities' at the 7th NOVO Symposium in Helsinki, Finland on November 15-16, 2018.

1 INTRODUCTION

Swedish healthcare needs to increase productivity to become able to meet demand projected for the future. However, public healthcare in Sweden has recently demonstrated a downward trend in productivity, as highlighted by the Swedish Association of Local Authorities and Regions (Palmgren & Eklund, 2014), the Swedish Agency for Health and Care Services Analysis (2013), and a public inquiry into Swedish healthcare efficiency in Sweden (SOU 2016:2). Meanwhile, the Swedish Ministry of Health and Social Affairs (2010) has projected an increased future demand for healthcare in Sweden due to shifts in demographic distribution. The Ministry has predicted that, by 2050, the number of older adults will have increased by 30% to form 25% of the population and that the average lifespan will have increased to 87 years. Those projections indicate that the group most in need of care will grow and require care for a greater part of their lives.

Healthcare institutions in Sweden provide a good quality of care (OECD, 2019) that generally ranks better than, or at least close to, the OECD average. However, Sweden also has the world's fifth-highest health expenditure in relation to GDP (OECD, 2019). As a consequence of changing demographics, it is predicted that those costs will increase by approximately 80% and staffing needs by 50%, both of which will result in a deficiency of personnel by some 65,000 full-time employees by 2030 (Swedish Ministry of Health and Social Affairs, 2010). Initiatives to increase productivity have foremost focused on applying so-called 'lean healthcare'; however, in many cases, lean initiatives have failed to deliver the promised benefits in healthcare (Radnor & Osborne, 2013). Among other setbacks, prescribing times for conducting activities that constitute flows has been problematic, capacity has often been estimated or based on experience, and production engineering methods are rarely used. The Swedish Agency for Health and Care Services Analysis (2013) gathered the work studies of doctors from hospitals around Sweden, and few of them had been conducted using rigorous methods. Indeed, most were self-assessments based on interviews about how much time personnel have spent on different activities. Such strategies are problematic, because the quality of self-reported data in healthcare is generally questionable (Ampt et al., 2007).

Within operations management, ideas about how to improve productivity, including lean production, often focus on flow efficiency and throughput (Schmenner & Swink, 1998). Performing well in those respects requires little variation in product features in the individual process and early sorting. However, in healthcare, product features in terms of patients' needs vary greatly even within patient groups due to secondary diagnoses. That factor partly explains why healthcare is organised around medical specialties and why those units are relatively independent. In another light, healthcare work involves both certain and uncertain tasks. Medical work is characterised by uncertainty and warrants an abductive approach, because medical professionals necessarily act based on incomplete information and search for additional information to reach the best understanding possible. Uncertainty also characterises patients' statuses and can influence the effectiveness of treatments. Variation in the patient population, even despite having the same condition and treatment, in terms of medical history and physical condition, for example, in combination with the uncertain nature of medical work, requires healthcare work to be organised with flexibility in mind. However, that same flexibility is detrimental to productivity, at least according to classic operations management theory (Schmenner & Swink, 1998). Although organisations normally focus on improving throughput in a bid to increase productivity while

remaining flexible, throughput time in healthcare is limited by human conditions, and patients cannot be forced to heal or recover faster. To remain flexible in production, work should be designed in local environments based on individual interests, experiences, and capabilities among the personnel. As a result, localised variation between departments, units, and personnel can allow work to be conducted with varying degrees of efficiency. In that case, how can production capacity be improved without compromising flexibility and the existing organisation of hospitals, clinics, and care units? In response to that conundrum, this licentiate thesis proposes to increase productivity by increasing the capacity of existing resources, namely by standardising the work methods of individual activities such that they are conducted more efficiently. In short, when what needs to be done is known, it can consistently be done quickly and effectively.

Against that same background, Sweden also currently experiences a nationwide shortage of healthcare personnel, including registered nurses and physicians (Swedish Public Employment Service, 2016). That shortage is predicted to continue persisting even despite increases in the number of employed personnel. The oft-proposed solution to overcoming the shortage is simply educating and employing more personnel. To date, research on shortages of registered nurses (e.g. Aiken et al., 2002; Needleman et al., 2002; Kane et al., 2007) has sought explanations by examining staffing levels, quality of care, nurses' job dissatisfaction, and their loss of motivation as a result of staff turnover and difficulties with recruiting personnel. By contrast, examining work activities, work methods, and the organisation of work directly has not been a scholarly priority. However, those factors in motivational theory—for instance, in Herzberg's motivation-hygiene theory in terms of work responsibility, work achievement, work conditions, and work environment (Hur, 2018))—are deemed to be essential aspects of work by both the Swedish Work Environment Authority and the Swedish National Board of Health and Welfare. Indeed, their regulations require all three to be specified:

The Swedish Work Environment Authority (AFS 2015:4, Translated from Swedish):

> 10 § The employer shall ensure that the employees are aware of
>
> 1. What work activities they should perform;
> 2. What results are to be attained by the work;
> 3. Whether there are specific ways of performing the work, and if so, then how;
> 4. What work activities should be prioritised when time is sufficient for all work activities that need to be performed; and
> 5. Whom they can ask for help in order to finish the work.

The Swedish National Board of Health and Welfare (SOSFS 2011:9, Chapter 4, Translated from Swedish):

> 2 § The healthcare provider […] shall identify, describe and establish the operational processes needed to ensure operational quality.
>
> 3 § The healthcare provider […] shall in every process according to 2 §:
>
> 1. Identify the activities included; and
> 2. Determine the order of those activities.
>
> 4 § For every activity, the healthcare provider […] shall develop and establish the routines necessary to ensure operational quality. The routines shall describe a set procedure for how

an activity should be performed and specify how the responsibility for performing the activity is distributed within the organisation.

Thus, work activities, work methods, and the organisation of work need to be addressed in order to improve both productivity and job satisfaction and, in turn, meet demand for healthcare in the future and overcome personnel shortages in healthcare. By focusing on work activities and work methods, this thesis addresses productivity in healthcare according to the basic premise that the potential to increase productivity in healthcare is significant, as can be made apparent by applying strategies of production engineering to standardise methods for different work activities. A comprehensive work sampling study of nursing work conducted at Sahlgrenska University Hospital and Skaraborg Hospital in Region Västra Götaland in Sweden shows that care ward personnel spend as little as 20–30% of their time on direct patient activities (L. Sundström & Almström, 2016), whereas the other 70–80% is spent doing other activities (e.g. administration and preparation) that need to be reduced in order to free up time as well as personnel (cf. Blay et al, 2014).

1.1 Aim and Research Questions

The focal problem of this licentiate thesis is work efficiency in healthcare. The aim of the research conducted for the thesis was to analyse how resource efficiency in manual work activities can be improved to also improve productivity and work environments. The research focused on the Swedish healthcare system, particularly in a hospital setting. For potential work activities to investigate, the research focused on inpatient care and indirect work with patients. By contrast, direct patient work is commonly in the jurisdiction of legal (medical) regulations and the performance of such work activities is often adjusted in the meeting between caregivers and caretakers. Improving direct patient work is thus in the domain of the medical professions and beyond the scope of this thesis.

Two research projects were conducted that form the empirical basis of the thesis: the Standard for Medication Work in Care Units project and the Systematic Work Activity Mapping project. The former project was launched to investigate how to design a standardised work area to be as efficient as possible for manual work activities at a large Swedish hospital—that is, to provide a solution for how medication work can be performed more efficiently. The latter project, by contrast, was launched to investigate how to systematically identifying and organising work activities at a large Swedish hospital in order to facilitate their subsequent improvement. During the completion of the two projects, the following research questions were examined:

1. How should medication work at a hospital care unit be improved to become more efficient?
2. How should work activities in hospital care units be systematically identified, collected, and organised?
3. How can resource efficiency for manual work activities in hospital care units be systematically improved?

Research Question 1 guided the first research project, whereas Research Question 2 guided the second. The research designs for the projects are presented in Sections 4.2.1 and 4.2.2. Research Question 3 asked what the projects revealed about improving resource efficiency at a Swedish

hospital beyond specifically improving medication work and systematically identifying, collecting, and organising work activities.

The structure of the licentiate thesis is as follows. The next chapter, Chapter 2, presents the theoretical framework and describes terminology related to resource efficiency, work design, work study, standards and standardisation, and design science research. After that, Chapter 3 describes the empirical setting: public healthcare in Sweden and in Region Västra Götaland, Sahlgrenska University Hospital, production development at Sahlgrenska University Hospital, and the role of the researcher. Next, Chapter 4 details the research method, including pre-studies at the Care Ward of the Future and research design outlines for the two projects: the Standard for Medication Work in Care Units project and the Systematic Work Activity Mapping project. Chapter 5 presents the results of the two projects, particularly how they progressed and their outcomes. For the Medication Work project, three workshops are described along with principles for designing the medication room, furnishings in the room, and the placement and prioritisation of furnishings. The implementation of the design is also presented. For the Mapping project the systematic work activity mapping method is presented, as well as the systematic work activity structure, work activity denomination, and specification of requirements for work activity mapping data structure and data management. In turn, those results of the projects are analysed and presented from the perspective of design science research. For each project, an appended paper is summarised, and the field problem and design problem as well as the object, realisation, and process designs are described. In addition, an analysis of designing for resource efficiency at hospital care units is presented, including about the relationship between resource efficiency and increased productivity, the creation of local standards and so-called 'standardisation sliding', stakeholder dynamics, and inter- and intra-organisational communication. In Chapter 7, the author reflects on being both an industrial doctoral student and an insider at the organisation studied as well as the generalisability of the results. Chapter 8 concludes the thesis by summarising how the overarching aim of the research was met, describing the research's implications for theory and practice, and articulating recommendations for future research.

2 THEORETICAL FRAMEWORK

This chapter constitutes the theoretical framework of the licentiate thesis. First the terms activities, resources, and efficiency are discussed, including a minor literature review on flow efficiency and resource efficiency in healthcare. Work design and Work study are introduced: How to design for efficient work and How to measure work respectively. As part of the latter, Work study analysis and Work sampling are described. Thereafter design science research is explained: What characterises the field, how it relates to other types of research, what it is concerned with, how to conduct it and how to frame it. Action research and the Breakthrough method are then commented on in relation to design science research. Last in the chapter is a summary section.

2.1 Resource Efficiency Terminology

This licentiate thesis concerns resource efficiency for manual work activities in healthcare. Therefore, it is relevant to consider the terms 'activity', 'resource', and 'efficiency' as well as their relation to 'productivity' and 'utilisation'.

Larsson (2018, p. 10) refers to activity as the point of contact between the healthcare system and patients. Such an activity is for example to take a blood sample. Together with waiting time activities make up the process that a patient follows through the healthcare system. Hedman (2016, p. 27) and Sundkvist (2014, p. 80) both describe activity as consisting of one or more 'sub-activities', which in turn consist of 'elements'. Elements correspond to basic physical movements and machine time related to operating equipment. When elements are put in a sequence they become a sub-activity, and when sub-activities are put in a sequence they can be described as an activity (ibid.). An activity has a purpose and an objective and is described as verb, e.g. control, treat, or perform, which infers action: to do something. Eklund (2008, p. 38) touches on activity when discussing efficiency in terms of the ratio between input and output of an activity, inferring that activity turns input into output i.e. some kind of alteration has been made.

Hedman (2016, p. 27) and Sundkvist (2014, p. 81) describe a (manufacturing) resource according to the ISO1030-1 definition as "any device, tool, and means, except raw material and final product components, at the disposal of the enterprise to produce goods or services". Sundkvist (2014, p. 81) explains that the underlying rationale is that resources perform activities and has two subclasses: human and equipment. Larsson (2018, pp. 15-16) states that in general a resource is something that adds value in the production of a good or service. In addition, Larsson treats resources in the form of facilities (e.g. patient rooms), workforce (e.g. nurses), and equipment (e.g. radiology equipment) in combination. Eklund (2008, p. 21) describe resources as being used, but not transformed or consumed by production, and generate capacity. Hedman (2016, p. 28) refers to four characteristics of (manufacturing) resources: 'administration', 'capability', 'constitution', and 'capacity. In short, administration concerns identification of a resource, capability is its ability to perform activities, constitution is equipment-related attributes, and capacity is a resource's potential workload. For resources in hospital production, Eklund (2008, p. 21) provides five grouping categories. A resource can be Dedicated or Shared, it can be Leading or Following, it can be Bottleneck or not, it can be Continuously or Intermittently available, and it can be Specialist-time as a shared resource or not. Shared resources are shared by production lines. Leading resources trigger production and

set capacity requirements on Following resources. Bottleneck resources limit system capacity. Continuously available resources are constantly available while Intermittently available resources are not. Specialist-time as a shared resource is a multi-functional resource shared between patient groups. Larsson (2018, p. 16) states that a resource may also be shared between activities, e.g. a physician who is required in diagnostic activities at a clinic and in treatment activities at one or more care units. Additionally, a resource may be considered as dedicated on the organisational level, but considered as time-shared when considering activities performed at the department, e.g. nurses dedicated to a certain department and a specific set of activities at a ward unit. Larsson, citing SOU 2016:2, remarks that the cause of productivity problems in the Swedish healthcare system is most often not a lack of resources, but the way the resources are used.

The distinction and relation between 'productivity', 'efficiency', and 'utilisation' is not always straightforward. Hedman (2016, p. 3) states that to measure productivity as a performance measure the efficiency or effectiveness of actions needs to be quantified. For production plants that corresponds to how efficiently a firm utilises its input to produce output and for the shop floor level productivity to the ratio of potential output to actual output of a process (ibid.; pp. 11, 13). Sundkvist (2014, pp. 84-85) notes that the relationship between a system's potential and realised output is commonly referred to as Capacity utilisation. Resource utilisation concerns the activities that are performed by a resource and is thereby distinct from Capacity utilisation. However, neither explicitly consider how activities are performed, e.g. if a resource performs an activity according to a time standard or not. Larsson (2018, p. 49) measured efficiency as throughput time, time-to-doctor, and as number of patients. Eklund (2008, pp. 38-40) defines efficiency as the amount of valued output in relation to input resources and distinguishes between three types of efficiency: Technical, Allocative, and Economic. The relation between resources, production, output, and the different types of efficiency is shown in Figure 1.

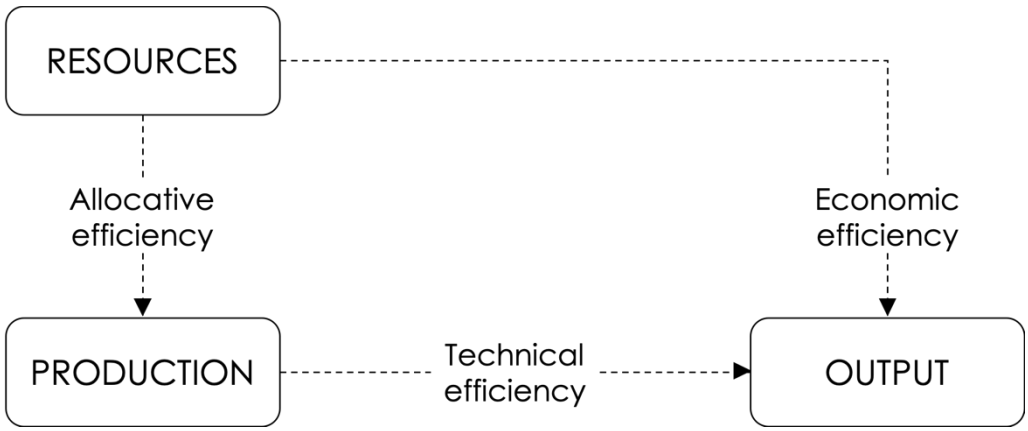


Figure 1. Different types of efficiency (Eklund, 2008; p. 38)

Technical efficiency refers to the amount of acceptable output per input by a resource or production unit, Allocative efficiency refers to variation in the amount of output produced depending on the distribution of resources to different activities, and Economic efficiency refers to the monetary cost of a produced unit of output (ibid.).

2.1.1 Key Concepts

This section outlines certain aspects of the theoretical framework to clarify and specify for this licentiate thesis. First, '(work) activity' and 'resource' is defined in relation to others' definitions. Second, the relation between flow, activities, and resources is described. Thereafter, Resource efficiency is defined in relation to productivity, efficiency, and utilisation.

This thesis uses the definition of activity also used by Hedman (2016, p. 27) and Sundkvist (2014, p. 80) of an activity as consisting of one or more 'sub-activities', which in turn consist of 'elements'. An activity has a purpose and an objective and is described in verb form, e.g. control, treat, or perform, which infers action: to do something. A work activity is something that needs to be performed in order to achieve some result.

The thesis also prescribes to the definition of resources used by Larsson (2018, pp. 15-16) as personnel (or workforce, facilities, and equipment, with the addition of Eklund's (2008, p. 21) distinction that resources as used, but not transformed or consumed by production, and generate capacity. This leaves out material and consumables. Since manual work in healthcare is the focus of this thesis, the principal resource is the personnel, i.e. the worker. Work often needs to be performed in a general or specific location (facility), often by using some type of equipment. However, neither can be utilised in manual work without the human resource.

With regards to work activities and methods, this licentiate thesis aims to address them from a work study perspective. Work study has its roots in production engineering and is concerned with the systematic and structured examination of work. It is primarily concerned with productivity, efficiency, elimination of waste and standardisation of best practices. A summary of the connection between work study principles, practices and research methods in relation to productivity, efficiency, elimination of waste, and standardisation compiled by the author is presented in Table 1.

Table 1. Principles, Practices and Research Methods related to productivity, efficiency, elimination of waste, and standardisation.

	Work activities	**Work methods**	**Work organisation**
Principles	Individuals should spend as much of their time as possible on value adding activities	Work activities should be carried out in their most efficient manner.	Specialization of work facilitates learning and efficiency through focus of effort. Multi-tasking has negative influence on efficiency.
Practices	Minimise the time spent on non-value adding activities or eliminate them completely.	Establish standardized work methods for activities that are conducted repeatedly. Work stations should be designed to facilitate efficient work.	Individuals should (only) carry out activities at the top of their competence. Other activities should be transferred to other groups of individuals with different skillsets.
Research Methods	Work sampling. Improve resource efficiency (through efficient work).	Work study analysis. Design methods.	Creation of work-roles based on competence needed for performing activities.

Work activities are rarely performed in isolation but rather in connection to other work activities, typically in some type of process or flow. Flows thus consist of activities performed by one or more resources that take some time to carry out. To exemplify the relation between work activities, resources, and flows one patient flow, one work activity A, and one resource R is used (Figure 2). A patient flow is the path traversed by a patient through a (part of) the healthcare system from the perspective of the patient.

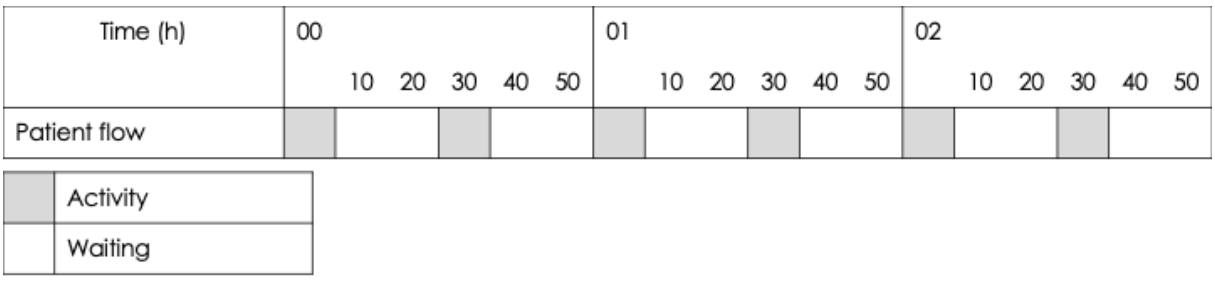


Figure 2. Patient flows consist of activities carried out by resources.

A patient flow consists of activities carried out by resources (and wait between activities). Activities take time to perform and resources have a certain available capacity. From the perspective of the

resource time is spent performing work activities (and wait between activities) (Figure 3). In other words, activities make up the utilised capacity of a resource.

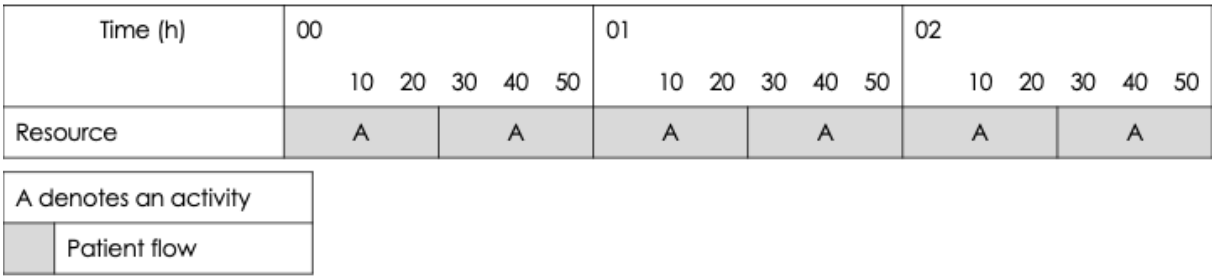


Figure 3. The time capacity of a resource is occupied by activities and activities take some time to carry out.

The time it takes to perform an activity can be divided into value-adding and non-value-adding time, based on if the time spent performing the elements to complete an activity contributes directly to its completion or not. Removing unnecessary elements from the work method and reducing distances reduces non-value-adding time. E.g. minimising the number of steps necessary to perform an activity results in reduced non-value adding time as walking is not a value-adding element. If the time to perform an activity is reduced by adding aids, reviewing the work method, and reducing non-value-adding time, that time is freed up for the resource that performs it. That freed-up time then becomes available resource capacity (Figure 4).

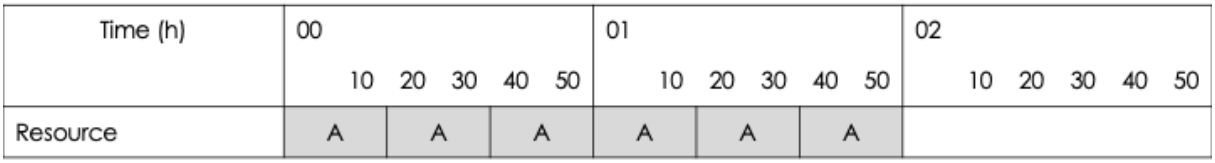


Figure 4. Resource capacity is freed up when activities are improved.

Flows can be parallel and consist of different activities performed by different resources shared across flows. E.g. a number of patients admitted to the same care unit cared for by a number of nurses. In the next example there are three patient flows consisting of three different activities performed by three different resources. Resources can be organised in different ways and to

exemplify two extremes are presented first. They can be organised to be dedicated to perform one activity shared by all flows (Figure 5).

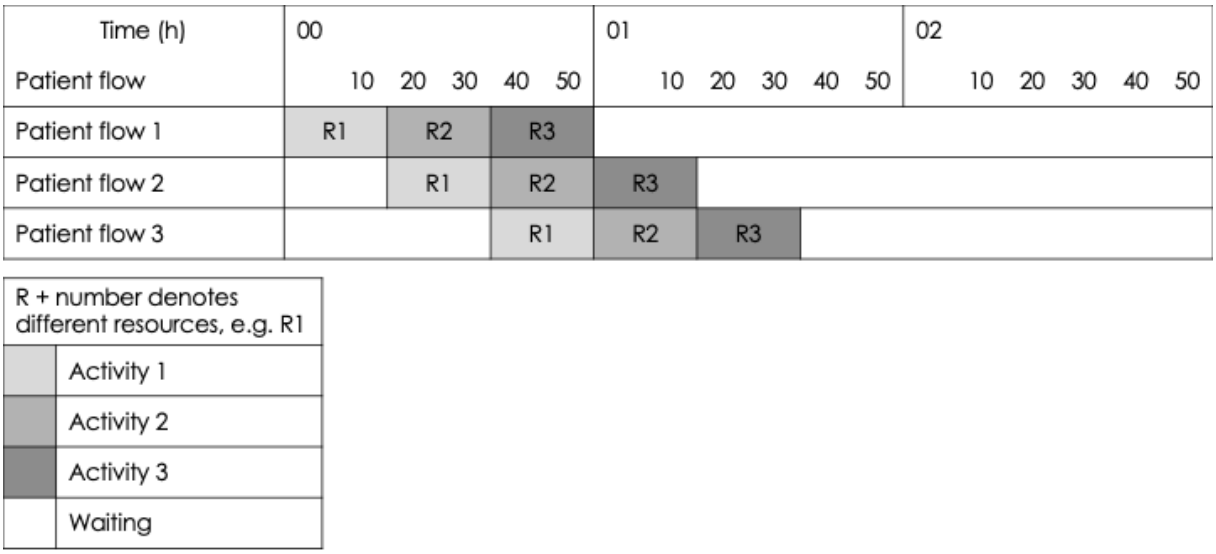


Figure 5. Resources shared across flows and perform one activity for all of the flows.

Resources can also be organised to perform several activities for one flow (Figure 6).

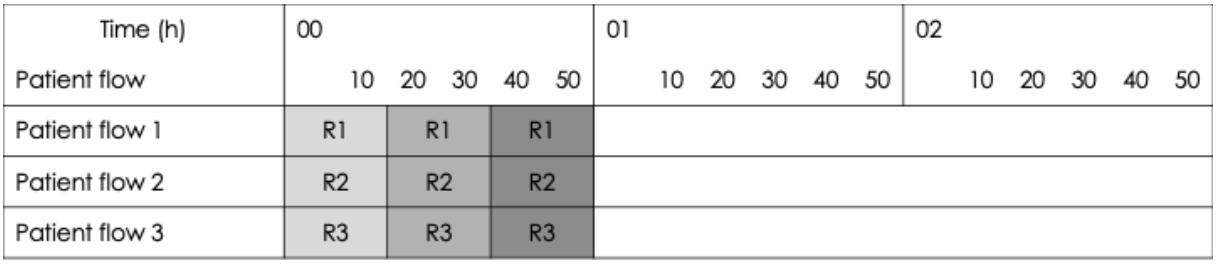


Figure 6. Resources dedicated to separate flows and to perform several activities therein.

These two above examples are extremes, and resources are seldom dedicated to just one activity or one flow (or a complete flow) in healthcare. In healthcare, the two previous modes of work are often combined, meaning that a resource performs several different activities across several different flows (Figure 7).

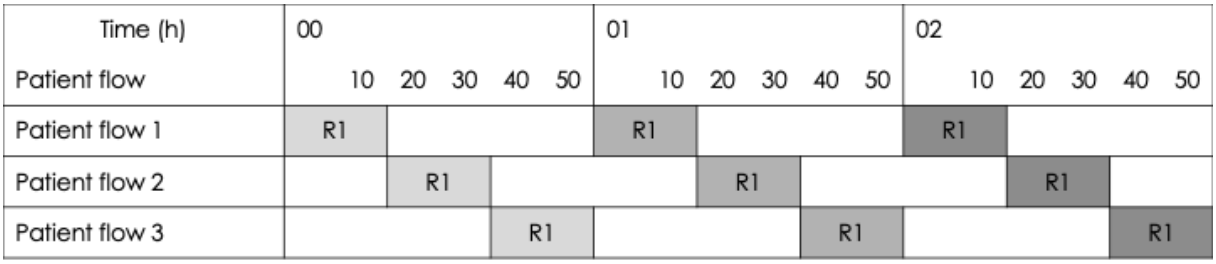
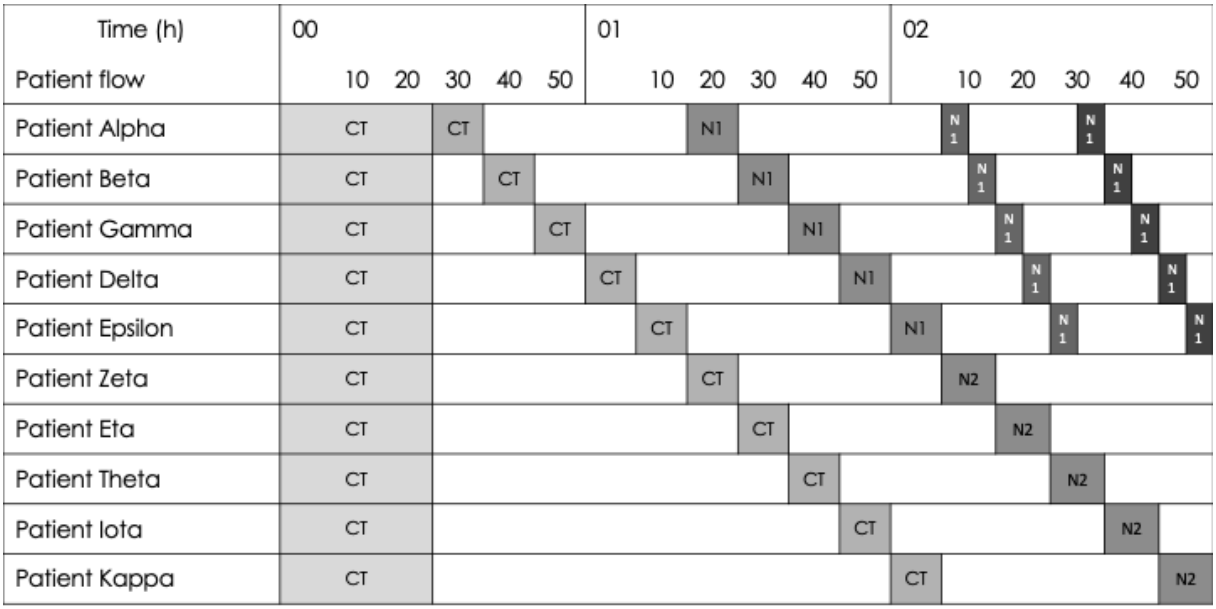


Figure 7. One resource performing several different activities for several different flows.

For example, a registered nurse at a care unit is typically dedicated to a group of five to seven patients and performs many activities in the care of these patients. Take the rounds at a care unit for example (Figure 8). At the example care unit there are 10 patients divided into two groups of 5 patients, each group presided over by a registered nurse. The care team do the rounds and consist

of a physician and the two registered nurses. For the purpose of keeping the example simple the focus is on the registered nurses and other staff such as assistant nurses, physiotherapists, or other staff potentially present normally are not included.



NX = Registered nurse X
CT = Care team (Physician and all registered nurses unless marked engaged at same time).

	Round start meeting
	Rounds
	Journal documentation
	Prepare pharmaceuticals
	Administer pharmaceuticals
	Waiting

Figure 8. Example of rounds at a care unit and two registered nurses performing activities for two groups of patients.

First the care team have a 30 min round start meeting to discuss the needs and status of the patients. Thereafter the care team visit each patient in turn, 10 minutes each. After registered nurse 1's patients have been visited, the registered nurse breaks off from the rounding care team to continue with activities pertaining to that group of patients. First registered nurse 1 documents the observations and decisions from the rounds in the patients' journals, 10 minutes per patient. By the time the care team has finished visiting all patients and registered nurse 2 starts to document registered nurse 1 is starting to prepare medications for each patient. When registered nurse 2 is done documenting, registered nurse 1 is done with administering medications.

The performance of an activity can also trigger a new activity (Figure 9). E.g. if a meal is to be served to a patient but the patient is asleep the meal needs to be put to the side and the patient provided food when awake again.

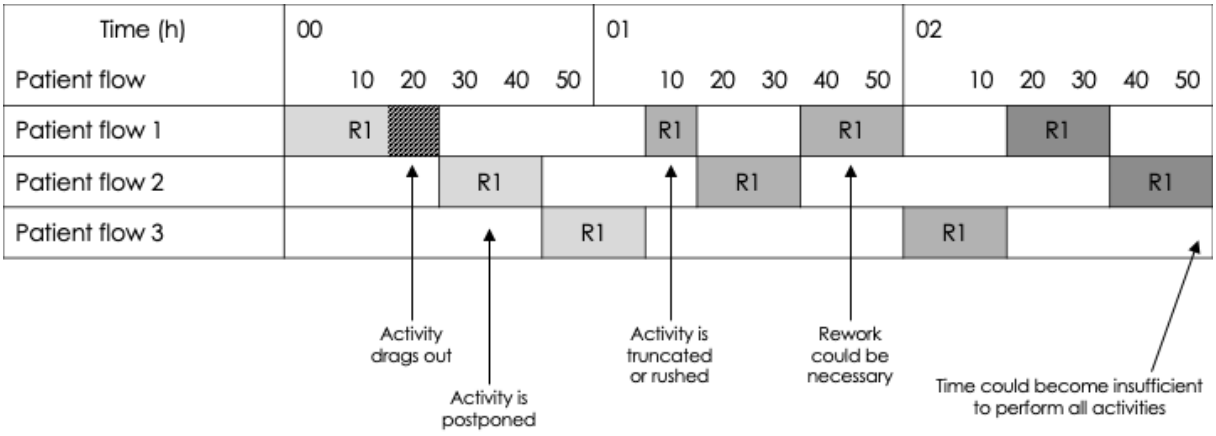


Figure 9. The performance of one activity can trigger new activities.

As illustrated in Figure 9 there are many ways for work to be disrupted: An activity can drag out, be postponed, be truncated or rushed, or require rework. Either as a consequence of a previous disruption or another circumstance. Disruptions can lead to insufficient time to perform activities. An activity can also trigger a new activity. E.g. observing some symptom that triggers the need for an investigation or treatment. A new activity to be performed is thus also a disruption to the pre-existing work sequence. Regardless if a resource is shared and responsible for one activity for several flows, dedicated to several activities for one flow, or a combination of several activities for several flows, any disruptions affect the performing of the following activities in the work sequence. This thesis is not concerned with if a resource is dedicated or shared. However, improving how work activities are carried out will affect a resource differently depending on if it is dedicated or shared. For a dedicated resource, an improved work method will reduce throughput time, thereby improving process flow. For shared resources an improved work method frees up time for the resource for other activities. A similar dynamic exist for leading and following resource activities where the benefit of a following activity is the delivery of it not the time spent performing it, e.g. a patient being medicated compared to preparing medication.

In Section 2.1 a distinction was made between 'productivity', 'efficiency', and 'utilisation'. Efficiency is a quantified measure of productivity of how efficiently input is utilised to produce output. The ratio between potential output and actual output is Capacity utilisation. When explicitly considering the activities executed by resources the ratio is referred to as Resource utilisation. However, as Sundkvist (2014, p. 85) points out, Resource utilisation does not consider how activities are performed. , e.g. if a resource performs an activity to a time standard or not. In this licentiate thesis this is what is referred to as 'Resource efficiency': How efficiently activities are performed by resources to produce output. By establishing, or designing for, a work method that gets work done in a shorter time, and performing work according to that work method, Resource efficiency is increased. If there is no standardised work method there is no information on the time required to perform an activity according to a normal pace and no information on whether work is efficient or not. This means Resource utilisation could be 100% (resource fully occupied) and work could be inefficient (Resource efficiency is low) simultaneously.

2.1.2 Improvement of Flow Efficiency and Resource Efficiency in Healthcare

Healthcare systems are focused on optimization, and methods from operations management are regularly employed to increase productivity. But what type of optimisation has been focused on? The aim of this literature study is to explore and categorise different types of resource efficiency and flow efficiency research activities that have been conducted in healthcare.

A systematic literature review using Scopus has been conducted. Title, Abstract, and Keywords have been searched for all years available to search. A delimiting search for "“Healthcare", Health care", OR "hospital(s)"" has been combined with several searches using different terms related to improving resource efficiency (Searches A-F) and improving flow efficiency (Search G):

A) 'Work study method*' OR 'work-study method*'

B) 'Pre(-)determined (motion) time system*'

C) 'Methods-time measurement' OR 'methods time measurement'

D) [Methods engineering][1]

E) ([Time and motion study][1] OR [Motion and time study][1]) AND [work][1]

F) 'Lean' AND ([Resource efficiency] [1] OR [Work efficiency] [1] OR [Work method][1])

G) 'Lean' AND ('Flow' OR 'Process' OR 'Value stream' OR 'Pathway') AND NOT ([Resource efficiency] [1] OR [Work efficiency] [1])

There have been no indication that the search terms used, which are from Industrial engineering terminology, are not be the terms used in healthcare improvement. The number of search results for each search category and range of their publication is shown in Table 2.

Table 2. Literature review search results.

Category	A	B	C	D	E	F	G
Number of results	2	1	4	5	71	7	1597
Years	1972-1981	1994	1973-2016	1953-1971	1952-2019	2011-2019	1982-2019

Results show that in healthcare research improving flow efficiency research outnumbers improving resource efficiency research by 17:1 (Search G compared to A-F). This is a strong indication that more research needs to be conducted on improving resource efficiency in healthcare.

This review highlights the need for more research on improving resource efficiency for efficient work methods. Improving resource efficiency to follow efficient work methods is beneficial both

[1] Searched in Scopus using curly brackets. Regular brackets are used here instead due to the reference management software EndNote X9 used writing this thesis falsely identifies curly brackets as broken references.

for maintaining high quality and good work environment. Scarcity of resources, staff shortages and increasing care complexity due to patient comorbidity increases the need to focus on improving resource efficiency to efficiently provide care that is less dependent on streamlined patient care processes.

2.2 Work Design – Methods Engineering

Methods engineering is a technique for improving and designing work methods (and work systems) by studying time and motion (Akiyama & Kamata, 2001; p. 4.3.). It is one of two basic techniques in Industrial Engineering, Work Measurement is the other. The objective of methods engineering is to improve labour productivity while safeguarding the ergonomic needs of personnel in relation to a work system (processes and activities performed to produce something). The classical definition of methods engineering is: 'The technique that subjects each operation of a given piece of work to close analysis to eliminate every unnecessary element or operation and to approach the quickest and best method of performing each necessary element or operation. It includes the improvement and standardisation of methods, equipment, and working conditions: operator training [and] the determination of standard time […]' (ibid., p. 4.5.). Methods engineering also includes analysis of production processes and work systems.

The basic way to perform methods engineering is to: i) Analyse the present work situation, ii) Identify problems, iii) Produce improvement ideas, iv) Select the best idea, and after implementation v) Standardise the new methods, vi) Ensure adoption of the new methods, and vii) Evaluate the impact of the new methods (ibid.). Akiyama and Kamata (2001) describe in detail the procedure for performing methods engineering step by step (Figure 10).

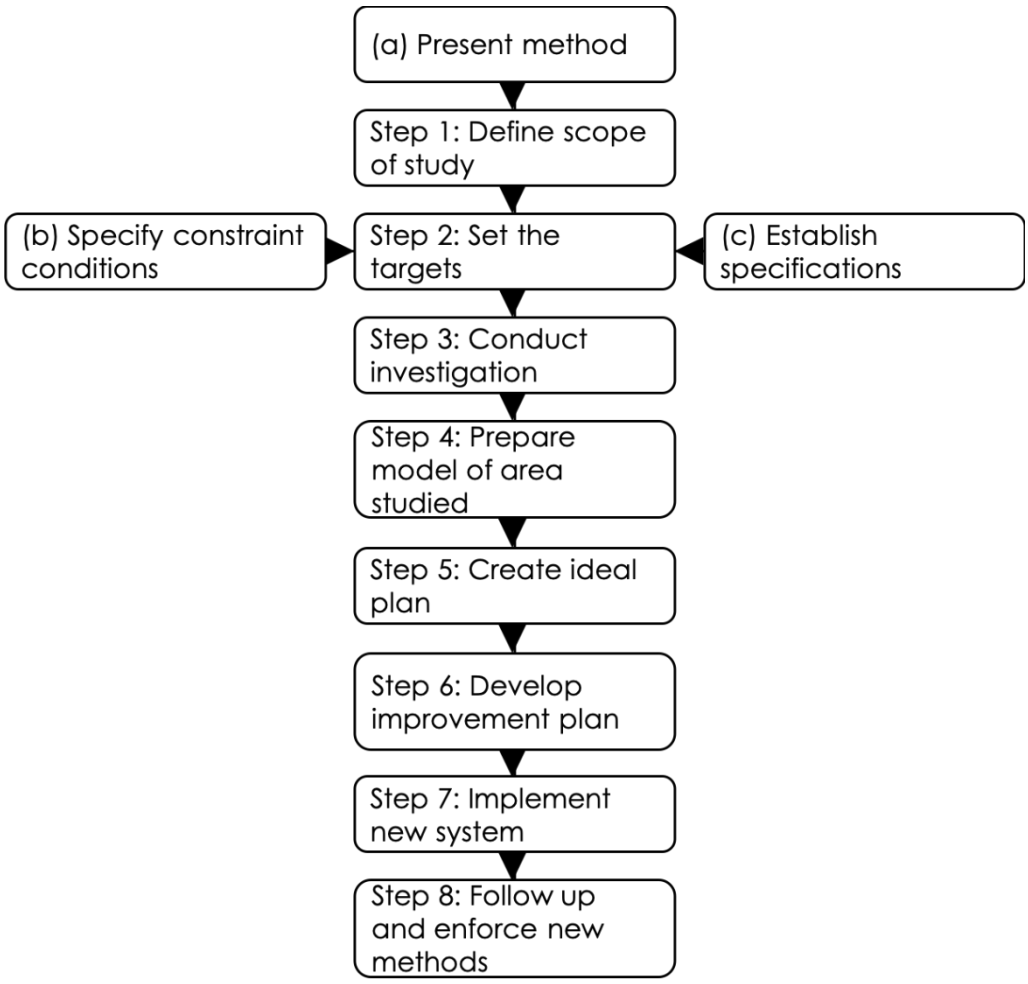


Figure 10. Procedure for methods engineering (Akiyama & Kamata, 2001)

Step 1 is to define the scope of study, to decide what is to be improved (Present method), and select the problem to be solved (Specify constraint conditions).

Step 2 is to set the constraints on the improvement activities, e.g. time and cost, and set the design parameters (Establish specifications), e.g. quality standards, throughput time, or production capacity. The goal to be achieve is set in regards to these specifications and constraints.

Step 3 is to conduct the analysis. The appropriate technique for analysis depends on what is to be analysed. Process analysis, motion study, time study, and work sampling are common techniques.

Step 4 is to model the area to be improved. Due to various factors the work system might change from day to day, e.g. if workers use different work methods or minor changes are being made at different work areas by moving equipment, material, or tools. A model is used to create a general work system to improve. To describe the model layouts, drawings, process charts etc. are used.

Step 5 is to develop the ideal method. If the focus of improvement is manual operations, industrial engineering improvement techniques (see Step 3) can be applied directly. If a multi-process work system is analysed, the relationship between processes needs to be studied first and depending on if the production system is deemed suitable for line production, cell production, or individual production possible changes to layout and work methods must be considered.

Step 6 is to select the improvement plan. The best plan is chosen based on evaluation standards such as e.g. reduction of cycle time, cost of improvements, time required for improvements, degree of technical difficulty, expandability, flexibility, safety, and matching required skill level of workers.

Step 7 is implementing improved methods. This requires preparation including the detailed design of equipment, installation, education and training of operators etc.

Step 8 is to follow up. A follow-up procedure needs to be created so that the target system performance can be upheld. Standard operating procedures are of primary importance for this. Using a measurement system utilising standard times to verify that performance is maintained at the level of the new design is also important.

2.3 Work Study – Work Measurement

Work Measurement is done in order to develop standard times for performing operations (Aft, 2001). Such time standards have conventionally been defined as 'the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method' (ibid., p. 5.3.). An average skilled operator is a representative of the people performing the task, a normal pace is an ideal work rate that can be maintained for an entire workday, and a prescribed method is the way of performing the work to (achieve) a certain quality. Standards, including time and work standards, provide important information for operating an organisation successfully: Data for scheduling, staffing, line balancing, materials requirement planning, system simulation, costing, and employee evaluation. If times for all operations, e.g. through work and time standards, are not known it will lead to problems: Production schedules cannot be set accurately. The number of personnel required cannot be determined accurately. The correct number of workstations for optimal work flow cannot be determined. The system cannot be accurately modelled and simulated. Allocation of production costs, including labour cost, to specific products cannot be made accurately. And assessing the performance of individual employees cannot be done lacking a performance standard to which to compare.

Conventionally, standards are developed in one of three ways: estimation, direct observation and measurement, or using standard data systems (ibid.). Estimation can be done in two ways, either by 'guess-timation', where a knowledgeable individual (or group of individuals) examines the work and estimates how long it will take to perform it, or by using historical data where a standard is developed using actual historical times and production quantities. A risk with historical standards is that work tends to expand as to fill the time available for its completion (Parkinson's Law). For developing standards by direct observation and measurement there are three common methods: time study, work sampling, and physiological work measurement. Time study is to record the time required to effectively perform the elements of work for a given operation. When tasks are highly repetitive and has short cycle times time study is effective to develop standards. Work sampling is used to study work activity. The proportions between categories of activity is determined by making a large number of observations at random intervals (see Section 2.3.2 for more detail). Work sampling is appropriate for developing standards for nonrepetitive work with long cycle times. Physiological work measurement is used to measure the physiological cost of human work, the energy required to perform work. Measuring heart rate and oxygen consumption is the most

common ways of doing this. Standard data systems are used to set work standards based on standard data: time data for groups of motions rather than single motions. Such data is used to determine time standards for work since each element of performing a work activity has an associated normal elemental time. It is used to set standard times based on a method of work and does not require study of said work and can thus be used to set times for new work, e.g. in a planning phase. Standard data systems based on microscopic data are called Predetermined Time Systems, which is a motion-based method of Work Measurement. By identifying and describing each motion necessary to perform an activity the time for a sequence of motions can be determined as well as a prescribed method of performing said work.

2.3.1 Work Study Analysis

The approach to standardizing work methods of specific work activities is work study analysis. There are different methods for conducting such analysis, in this licentiate thesis the method used is Methods Time Measurement – Sequence-based Activity Method (MTM-SAM) analysis. MTM-SAM is a type of Predetermined Time System that generates a norm time for an analysed operation based on the MTM standard (International MTM Directorate, 2004). In MTM-SAM work activities are broken down to the sequence level where a typical sequence includes elements such as Reach, Grasp, Move and Release of an object. Predetermined Time Systems provide information about manual work in terms of basic human motions (Aft, 2001). Systems can be classified as motion-based, action-based, or activity-based. Motion-based systems are made up of basic motions that cannot be broken down into smaller time elements. Action-based systems combine basic motions into actions. Activity-based systems combine basic motions and action elements and put them together in a sequence to represent an activity, e.g. pick up and move object from A to B. There are several benefits to pre-determined time systems. They require that a method is analysed in detail before establishing a standard. Thereby, inefficiencies and problems of the work methods are identified and a well-documented procedure for performing the task is created. Pre-determined time systems eliminate subjectivity in performance rating since a performance norm is inherent in the system. They also make it possible to visualise and describe a standard while it is still in the planning phase and does not require that the work pertaining to the standard is performed.

Productivity in Work Study Analysis can be described in terms of method, performance, and utilisation (Table 3). This is distinct from productivity as commonly known as output through input. Productivity can be expressed in the following equation (Almström, 2013; Sakamoto, 2010):

$$\text{Productivity} = M \times P \times U$$

Table 3. Productivity factors, variables and definition (Almström, 2013)

Factor	Variable	Description
Method (M)	-	The ideal or intended productivity rate based on how the work is designed to be performed in the ideal case.
Performance (P)	Personal performance rate	The personal performance rate is affected by the individual's physical ability and his or her motivation to work at a high speed (relative the MTM norm), independent of work task
	Skill based performance rate	The skill based performance rate is the individual's speed at performing a specific work task depending on the training and experience the individual has for the task.
Utilisation (U)	Need based utilisation rate	The need based utilisation rate depends on the need for relaxation and personal time. It is often regulated by agreements at the work place. It includes paid breaks and losses before and after a break.
	System design utilisation rate	The system design utilisation rate is defined as the balance losses designed into the system. It can be balance losses on an assembly line as well as losses in a semi-automated work station.
	Disturbance affected utilisation rate	Disturbance affected utilisation rate corresponds to the losses caused by different random disturbances. It includes the lost time from discovery of the disturbance until the work is performed at full speed again.

The method factor (M) is defined as the ideal or intended productivity rate. It is the inverse of the ideal cycle time for the specific work task. To determine the ideal cycle time for manual work tasks it is necessary to use a predetermined time system.

The performance factor (P) corresponds to the speed the work is carried out at in relation to the ideal cycle time. The standard working pace in MTM is set to be valid for a "normal person" working at this speed for 8 h a day and for the whole working life without getting exhausted or injured. The performance rate is lower for not fully trained workers.

The utilization factor (U) represents the time that is spent on performing the intended work in relation to the total planned time. Utilization can never go beyond 100%. The planned production time is usually defined as the paid working time minus planned stops.

2.3.2 Work Sampling

Work sampling is a tool and type of study used in order to determine the proportions of the total personnel time devoted to specific work tasks. It is an alternative to Continuous Stopwatch Study based on sampling of activities (Brisley, 2001). Work sampling works according to the Law of Probability, that a small number of chance occurrences tends to follow the same distribution pattern as a larger number of chance occurrences. It is an effective way of determining the utilisation of personnel and especially to get a measure of activities that are outside of the core (or value-adding) activities, such as supporting activities and disturbance handling. Work sampling is an established method for carrying out work studies in hospital settings (Blay et al., 2014).

A work sampling study results in a distribution of time spent on different activities. In short, to prepare for a work sampling study one needs to do the following: a) Establish work tasks to observe (set list or free text), b) Set a schedule for observation, c) Determine the interval of observation (e.g. every 30 s), d) Calculate the number of observations required in reference to a confidence interval, and e) Decide on co-observation of subjects (switching between subjects or not). Work sampling can be perceived by personnel as excessive management control or spying (Brisley, 2001). Lack of communication is often a reason for such perceptions. Therefore it is important to talk with the personnel to clarify why work sampling is conducted in order to gain acceptance. Brisley (ibid.) provides a more extensive instruction than the above for how to prepare for a work sampling study:

- **Gain acceptance of work sampling**
- **Define the problem**
    - Determine what information is required.
- **Make an observation recording form**
    - Number of people to be observed (e.g. Registered nurse, Assistant nurse).
    - Classification of the activities for which to collect data.
- **Select frequency of operation**, based on**:**
    - Nature of the operation.
        - Repetitive or not, Infrequent or not, affects length of observation time.
    - Physical limits.
        - E.g. if an observer needs to cover great distances when switching subjects.
    - Total numbers of observations required and time limit.
        - E.g. if 10,000 observations are required for accuracy and there are ten eight-hour shifts available to observe means an observation needs to be done every 28.8 s (125/h).
- **Determine time of trips, on a random basis**
    - Randomness of observation is stressed to reduce sampling errors.
- **Estimate the number of observations that will be needed**
    - A larger number of observations provides greater accuracy (up to a point after which more observations are not worthwhile). The estimated number of observations is needed in order to plan the frequency of observation, number of observers, and the length of the study.
- **Evaluate methods by which biased readings may be reduced**

- An observation would register a subject to be working even if the activity is being conducted inefficiently or with unnecessary elements.

- **Have a session with the observer(s)**
  - Discuss and define each element to be observed and recorded with the observers to avoid inconsistent designation of observations during registration.

Determining the estimated number of observations required for a work sampling study begs some elaboration. Since work sampling is based on probability, variability needs to be taken into account in terms of how accurate of a result is desired (ibid.). The statistic formula for calculating the number of observations (*n*) required is as follows:

$$n = \frac{z^2 p(1-p)}{\sigma^2}$$

p is the percentage occurrence of any element selected, expressed as a decimal, 0.01 = 1% occurrence. σ is the standard deviation and standard error, arbitrarily determined, expressed as a decimal, 0.01 = 1% error. z is an expression of the level of confidence *a* and is the distance, expressed as standard deviations, between a perpendicular erected at the arithmetic mean and a perpendicular erected at specific points to the left and right of the mean. *a* is the selected level of confidence, expressed as a decimal (0.95 = 95% confidence). The chosen level of confidence provides the distance in standard deviations z, see Table 4.

Table 4. Distance in standard deviations (z) for levels of confidence (*a*).

z (+ and -)	*a*
1.000	0.68
1.645	0.90
1.960	0.95
2.567	0.99

To exemplify, the number of observations (*n*) required to observe elements occurring more often than 5% of the time (*p*), with a confidence (*a*) of 95%, and an acceptable error (σ) of 5% is calculated as follows:

p = 0.05, *a* = 0.95, z = 1.960, σ = 0.05

$$n = \frac{z^2 p(1-p)}{\sigma^2}$$

$$n = \frac{1.960^2 0.05(1-0.05)}{0.05^2}$$

$$n = 72.99\ observations$$

Each element needs to be observed at least 73 times.

2.4 Standards and Standardisation

This section is included as a justification to why this licentiate thesis is concerned with the establishing of standards for improving resource efficiency.

Standards come in many shapes and by many names: Technical Standards (e.g. Standard specifications and Standard methods), Engineered Labour Standards, Standard Operating Procedures, and more. In this licentiate thesis two general types of standards are distinguished between: The way of performing some activity (e.g. work method) or the composition of something (e.g. a design). A standardised work method typically defines the prescribed (step-by-step) method for a trained employee, working at an acceptable pace, to perform a defined amount of work in a defined amount of time in order to efficiently achieve a specified (quality of) output. Both types of standards will be referred to as 'standards' unless a distinction needs to be made.

In essence, the justification behind why standards are needed is that "there can be no improvement where there are no standards" (Imai, 1986, p. 74). First and foremost, a standard sets a benchmark to which alternatives may be compared (Bishop, 2001). They also provide the means to accurately determine the potential of improving current practices and evaluate alternatives. In other words, standards are not necessarily the best variant or optimal method at first, but provide a common ground for wide-reaching improvement in an organisation. Without standards, improvements to current practices remain local improvements and become just another variant among many. Additionally, the more number of personnel that perform a work activity, the greater the aggregated time saved by standardising and improving that work activity. Typically standards provide a foundation for small improvements to accumulate over time and contribute to overall organisational performance (Berger, 1997).

If a work activity or process can be measured in some production unit that can be quantified, it is a potential candidate for standardisation (Bishop, 2001). Standardisation allows companies to maximise resource utilisation by reducing the time and effort wasted when using sup-optimal work methods. The elimination of such waste is the focus of standardisation of work. By using standards an organisation can use its personnel more efficiently. This will also improve the utilisation of other resources, e.g. less downtime or more operating cycles for equipment or other resources previously preceded by bottlenecks. The benefits of properly implemented standards are several: Personnel will know what is expected of them. Costs can be better controlled since an accurate measurement of costs associated with a work activity or process is provided. Resources can be scheduled efficiently since it will be known how different processes interact with each other and their duration so that they can be coordinated and synchronised. This is particularly important for balancing a sequence of work since the bottleneck sets the pace for the whole sequence.

Standards can be more or less detailed, and concern different levels of an organisation. e.g. both company (or government) policies and operator work instructions are standards (Bishop, 2001). Standards may be established in different level of detail, both if there are highly standardised or highly diverse work practices, for example as detailed step-by-step instructions or as system standards (Berger, 1997). An organisation producing products or services that are unique with unique features tailored to individual customer demands generally applies less detailed standards compared to an organisation where such variations are low. Depending on the level of

standardisation of both the product design characteristics and the production process choice standards for work can be indirect and/or direct (Table 5).

Table 5. Types of standards for operator work process as a function of product design characteristics and process choice (Berger, 1997).

STANDARDISATION RELATED TO PRODUCT DESIGN CHARACTERISTICS	STANDARDISATION RELATED TO PROCESS CHOICE	
	Low General technology, broad work content, labour intensive, decentralised control.	High Dedicated technology, narrow work content, capital intensive, centralised control.
Low Unique products and custom designs.	*Indirect standards* for both task inputs and operating procedures, e.g. through skills, organisation, information and communication.	*Indirect standards* for task inputs, e.g. through skills etc. *Direct standards* for operating procedures, e.g. through Standard Operating Procedures
High Standard products and fixed designs.	*Direct standards* for task inputs, e.g. through specified designs. *Indirect standards* for operating procedures, e.g. through skills etc.	*Direct standards* for task inputs, e.g. through specified designs. *Direct standards* for operating procedures, e.g. through Standard Operating Procedures.

In short, indirect standards are e.g. standardisation of skills, organisation, information, or communication. Direct standards are e.g. Standard Operating Procedures or technical standards. Indirect standards are useful to support flexibility to meet varying customer demands and direct standards are useful as support for highly standardised work activities and processes. In healthcare, the level of standardisation related to process choice and to product design characteristics are high and low for different types of care and spans the scale between the extremes. Berger (1997) exemplifies four cases from different industries for the different combinations of product characteristics and work process standardisation, in this licentiate thesis the cases have been adapted to exemplify these combinations in healthcare (Table 6).

Table 6. Four cases of product characteristics and work process standardisation combinations in healthcare.

Low Product Design Characteristics and Low Work Process Standardisation
Rare diseases requiring tailor-made treatments. Relies on the personnel's ability to interpret and transform input and set up the work process on a case-by-case basis. Detailed standards of methods and procedures are difficult to establish due to great uncertainty and variation. System standards are mainly to ensure formal skills.
Low Product Design Characteristics and High Work Process Standardisation
Emergency hospital care. Inputs to emergency care personnel can be vague and symptoms must be interpreted to set a diagnosis based on the skill and knowledge of the personnel. After a patient has been diagnosed the treatment work procedure is fairly standardised.
High Product Design Characteristics and Low Work Process Standardisation
Some care unit work. The details in work procedures are up to individual preference and discretion. Input (e.g. materials) and end result are specified but the procedures to achieve the result are less standardised. For example, if a medicine cart is brought from room to room when administering medications or left in the medication room. Or what type of connector mechanism is used when diluting powder medications with injection fluid. Or if a care unit is rounded by all nurses or team-by-team and if those teams then correspond to one or different rounding physicians.
High Product Design Characteristics and High Work Process Standardisation
Clinics and laboratories. Clinic patients visit the clinic for specific conditions that commonly fall inside a regular procedure and conduct. Similarly for lab work where samples of different kinds are to be analysed in different ways according to specific procedures.

With regards to standards and standardisation two general types of standards are distinguished between in this licentiate thesis: The way of performing some activity (e.g. work method) or the composition of something (e.g. a design). A standardised work method typically defines the prescribed (step-by-step) method for a trained employee, working at an acceptable pace, to perform a defined amount of work in a defined amount of time in order to efficiently achieve a specified (quality of) output. Both types of standards will be referred to as 'standards' unless a distinction needs to be made.

2.5 Design Science Research

To design is to make changes to a given system, transforming situations to achieve improvements. (Dresch et al. 2015, p. 47). Since the research in this licentiate thesis aims to design methods and solutions for improving the resource efficiency of manual work in healthcare. Design science research has been identified as a suitable approach in which to frame those efforts.

Design science is a body of knowledge on designs and designing (van Aken, 2014). The aim of design science is to prescribe solutions to given problems and to help reduce the existing gap between theory and practice based on the idea that research results in the form of prescriptions are easier applied by professionals (van Aken, 2004). Design science research is research focused on problem solving (March & Storey, 2008). The idea is to understand a problem, create a solution to the problem, evaluate the solution, and enable an improved situation. The research is concerned with *design problems* and is driven by *field problems* (van Aken, 2014). A field problem is a situation in reality that can or should be improved and a design problem is the problem of how to solve or improve the field problem. In addition, design science research also deals with the effects of artefacts in context. An artefact is the symbolic or physical representation of design concepts (Gill & Hevner, 2011).

Design science is positioned as an epistemological paradigm that can guide research toward problem solving and artefact design (van Aken, 2004). Van Aken (2004) outlines three categories of scientific disciplines based on different paradigms: The formal sciences, The explanatory sciences, and The design sciences. The formal sciences, such as mathematics, are concerned with building propositions whose main test is their internal logical consistency. The explanatory sciences, such as the natural sciences and much of the social sciences, are concerned with describing, explaining, and possibly predicting phenomena and typically result in a causal model. The design sciences, such as the engineering or medical sciences, is concerned with developing knowledge to be used in designing solutions to problems, either to solve construction problems (creating something new) or improvement problems (improving the performance of something existing). Academic research tends to be based on the paradigm of the explanatory sciences and be description-driven. This has led to a utilisation problem for management theory developed by the academic community where the business world, generally speaking, ignores research coming from business schools and follow management fads instead. Design science, as prescription-driven research, is a complement to description-driven research used to develop field-tested and grounded solutions to serve as archetypes for problem solving. The main differences between description-driven and prescription-driven research are presented in Table 7 below (from van Aken, 2004, p. 236, modified).

Table 7. The main differences between description-driven and prescription-driven programmes (from van Aken, 2004, modified)

Characteristic	Description-driven research programmes	Prescription-driven research programmes
Dominant paradigm	Explanatory sciences	Design sciences
Focus	Problem focused	Solution focused
Perspective	Observer	Player
Logic	Hindsight	Intervention-outcome
Typical research question	Explanation	Alternative solution for a class of problems
Typical research product	Causal model; Quantitative law	Tested and grounded design propositions*
Nature of research product	Algorithm	Heuristic
Justification	Proof	Saturated evidence

* The original term in the table was 'technological rules' but the concept has been developed into 'design propositions' (Dresch et al., 2015, p. 55).

Design science research strives to provide alternative solutions for a class of problems. A class of problems is a grouping of a set of problems that have artefacts related to their solution that are useful for action in organisations (Dresch et al., 2015, pp. 104-105). Examples of classes of problems and related artefacts are: Production and planning control (artefact: Kanban), Cost management (artefact: Activity-based costing), and Process mapping (artefact: Value-stream mapping). A class of problems typically have a plurality of related artefacts. The principal research product of design science research is a generic design supported by a design proposition (van Aken et al., 2016). A generic design is an artefact to be introduced or applied to address a field problem. It should be field tested to establish that the intervention results in the intended outcome (pragmatic validity) and be well-tested, well-understood, and well-documented. Design propositions are templates that can be used to develop solutions for a class of problems (Dresch et al., 2015, p. 55). A design proposition provides insight on where and how the generic design is to be used (van Aken et al., 2016). Design propositions follow the basic logic of 'If you want to achieve Y in situation Z, then use generic design X'. They can be formulated according to the CIMO-logic (Denyer et al., 2008). The components of the CIMO-logic are explained in Table 8.

Table 8. CIMO-logic – The components of design propositions. (Denyer et al., 2008)

Component	Explanation
Context (C)	The surrounding (external and internal environment) factors and the nature of the human actors that influence behavioural change. They include features such as age, experience, competency, organizational politics and power, the nature of the technical system, organizational stability, uncertainty and system interdependencies. Interventions are always embedded in a social system and, as noted by Pawson and Tilley (1997), will be affected by at least four contextual layers: the individual, the interpersonal relationships, institutional setting and the wider infrastructural system.
Interventions (I)	The interventions managers have at their disposal to influence behaviour. For example, leadership style, planning and control systems, training, performance management. It is important to note that it is necessary to examine not just the nature of the intervention but also how it is implemented. Furthermore, interventions carry with them hypotheses, which may or may not be shared. For example, 'financial incentives will lead to higher worker motivation'.
Mechanisms (M)	The mechanism that in a certain context is triggered by the intervention. For instance, empowerment offers employees the means to contribute to some activity beyond their normal tasks or outside their normal sphere of interest, which then prompts participation and responsibility, offering the potential of long-term benefits to them and/or to their organization.
Outcome (O)	The outcome of the intervention in its various aspects, such as performance improvement, cost reduction or low error rates.

The CIMO-logic is made up of four components: Context, Intervention, Mechanisms, and Outcome. The logic follows that for a particular problem in a Context, a particular Intervention is useful and through certain Mechanisms will produce a certain Outcome. In other words, in what situation a certain solution is viable, how to achieve it, and what will happen. The CIMO-logic describes a design proposition as a combination of Interventions (I) that invoke particular generative mechanisms (M) (Denyer et al., 2008). Thus the different aspects of the design proposition is described and a guide for application provided. A solution will have three designs, an *object-design*, a *realisation-design*, and a *process-design* (van Aken, 2004). An object-design is the design of the intervention or of the artefact. A realisation-design is the plan for the implementation of the intervention or the constructing of the artefact. A process-design is the plan for the problem solving cycle, i.e. the method to be used to design the solution to the problem.

The Problem Solving Cycle (also known as the regulative cycle) is used to tackle design problems and provide generic designs and design propositions (van Aken, 2004; van Strien, 1997). The problem solving cycle is as follows:

1. Define the problem out of its 'messy' context
2. Plan the intervention
    a. Diagnosis of the problem situation (A hypothesis of the causes and possible remedies)
    b. Design of alternative solutions
    c. Selection of solution
3. Apply the intervention
4. Evaluate the intervention

The problem solving cycle often follows a negative feedback loop of an iterative character in that if the desired outcome has not yet been achieved the cycle starts over. In addition, the process of designing solutions (generic designs and design propositions) is performed in iterations of synthesis-evaluation cycles (van Aken, 2014). In the synthesis step a version of a design that could solve the design problem is made, which also satisfies requirements. In the evaluation step the 'paper design' is analysed to see if it meets specifications. If it does not, the design is adapted and evaluated again until it does and can then be transferred from paper to reality.

After the design has been tested in theory, it needs to be field tested in practice to determine to which degree the design affects system performance (van Aken et al., 2016). The aim of testing is to produce input for redesign. It is worth noting that, tests should test for direct outcomes of the intervention and not ultimate ones. The researcher's task is to only provide evidence of direct outcome. This is due to many other factors being prevalent that affect ultimate outcomes. E.g. if a work activity is improved in regards to time consumption evaluation should focus on the time reduced for that work activity and not on an ultimate outcome such as productivity since that depends on how the saved time is spent. After testing has produced input for an optimised solution, input needs to be produced to generalise the design (ibid.). Field tests must produce evidence of the generic design being applicable in the general context. This is achieved through saturation of body of evidence, which is when further testing no longer adds valuable input. However, the design only describes the formal system. In social and socio-technical systems (involving people) there are factors such as implementation, communication and motivation, which make up an informal system around the design that affect performance. Alternative explanations for test results need to

be eliminated in order to determine if the design produces the desired outcome. Therefore, it is the quality of testing that determines the quality of the research. The fundamental quality criteria for design science are Pragmatic validity and Practical relevance and centres on effectiveness (ibid.). Pragmatic validity refers to how strong the evidence is that the design will produce the desired outcome and whether the realised design will work after implementation in a particular context. Practical relevance refers to in what way the design makes a valuable contribution to addressing a significant field problem. Information on Pragmatic validity and Practical relevance are produced during field tests, which are key In design science research. Field testing often starts with alpha testing by the designer(s) followed by beta testing by stakeholders and can be complemented by peer reviews or focus group discussions with experts, operators, and other stakeholders.

This section on design science research has brought up many different terms that are related to each other. For the benefit of the reader a short summary and relation of some terms are presented in Table 9.

Table 9. A selection of key design science terms and their explanations

Term	Explanation
Field problem	A problem situation in reality that can be improved. (Drives design science research)
Design problem	The problem of solving or improving the field problem. (The concern of design science research)
Solution	The research product of design science research. A generic design supported by a design proposition. Will have an object-design, realisation-design, and a process-design.
Generic design	An artefact to be introduced or applied to address a field problem.
Design proposition	A template that provides insight on where and how the generic design is to be used. Consists of a combination of interventions. Follows the basic logic of 'If you want to achieve Y in situation Z, then use generic design X'.
Object-design	The design of the intervention or of the artefact.
Realisation-design	The plan for the implementation of the intervention or constructing of the artefact.
Process-design	The plan for the Problem Solving Cycle. (The method used to design the solution to the problem.)
Artefact	The symbolic or physical representation of design concepts
Intervention	To interfere with the outcome or course especially of a condition or process, as to prevent harm or improve functioning (Merriam-Webster Dictionary, 2020).

The analysis of the research projects will focus on certain aspects of design science research and look at each of them separately. These are the Field problem, the Design problem, and the Object-, Realisation-, and Process-designs. Field problems and Design problems are likely to have changed and been modified throughout a project due to increased knowledge of the problem. These will be reviewed. The development of a Solution to a problem will be reviewed in its constituent parts: Object-design, Realisation-design, and Process-design. The latter is reviewed according to the Problem Solving Cycle (see Section 2.5).

2.5.1 A Comment on Action Research

When I have explained to other researchers that I am doing design science research I have often received the comment "Oh, so like action research?". Therefore I thought it poignant to explain the difference between the two as this is a question that is likely to recur.

Action research and design science research are similar in some ways. Järvinen (2007) compares the cyclical process of action research with a general methodology of design research and finds that they match. He also finds similarities between their fundamental. The cyclical process of action research consists of five phases: 1. Diagnosing, 2. Action planning, 3. Action taking, 4. Evaluating, and 5. Specifying learning (Figure 11).

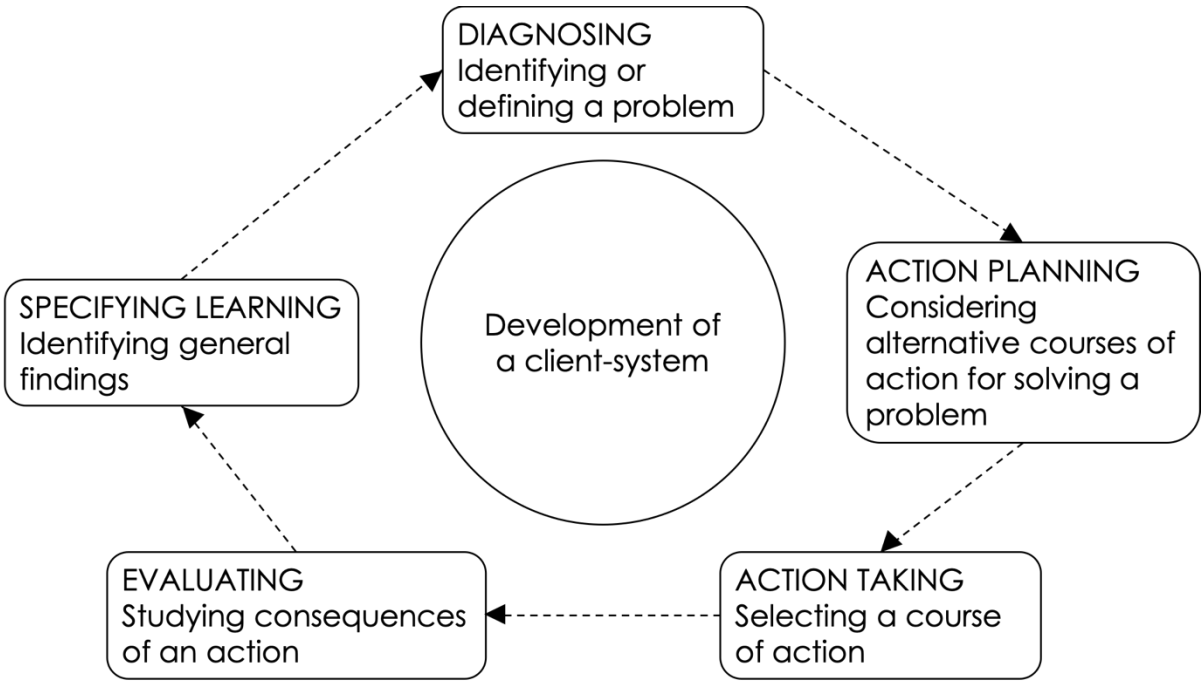


Figure 11. The cyclical process of action research (Susman & Evered, 1978).

The general methodology of design research that Järvinen compares the cyclical process of action research to also consists of five phases: 1. Awareness of the problem, 2. Suggestion, 3. Development, 4. Evaluation, and 5. Conclusion (Figure 12). (Note: The general methodology of design research that Järvinen (2007) refers to is from a 2004 paper by Vaishnavi and Kuechler that is unavailable. However, the same model is published by the same authors in Kuechler and Vaishnavi (2008).)

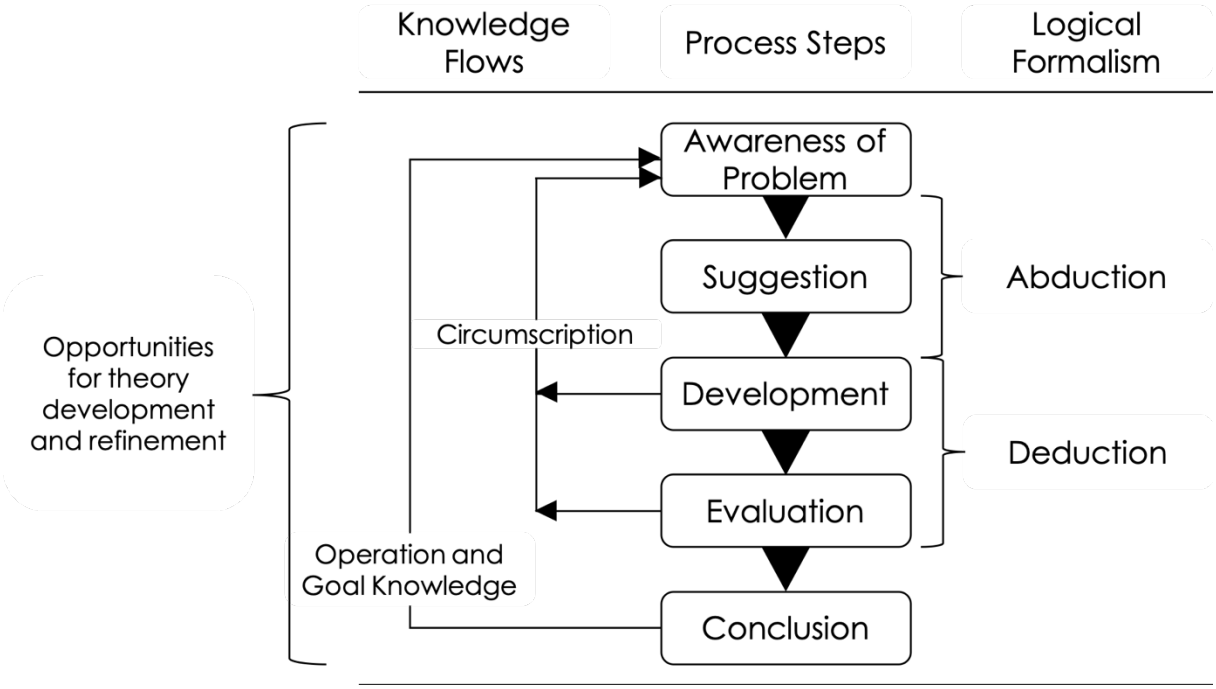


Figure 12. The general methodology of design research (Kuechler & Vaishnavi, 2008).

However, the paradigmatic assumptions, research interests, and activities of design science research and action research differ more or less dramatically depending on research purpose (Iivari & Venable, 2009). A comparative summary of the paradigmatic assumptions is presented in Table 10.

Table 10. Summary of the paradigmatic assumptions of action research and design science research (Iivari & Venable, 2009)

Paradigmatic dimension	Action research	Design science research
Ontology	Anti-realism	Realism or anti-realism
Epistemology	Mainly anti-positivism	Mainly positivism, but also anti-positivism especially in evaluation
Methodology	Idiographic	Constructive (building) Nomothetic (evaluation) Idiographic (evaluation)
Ethics	Means-end Possibly interpretive Unlikely critical	Means-end Possibly interpretive Possibly critical

Fundamentally, there is a problem of categorisation regarding stating that action research and design science research are essentially the same: action research is a research method and design science research is more of a research orientation (in which one might use action research) (ibid.). When comparing the two, action research holds reality as socially constructed (Anti-realism) while design science research also accepts that reality can be relatively immutable and exists regardless of

if it can be described or interpreted (Realism). Action research also emphasizes the need to understand and interpret social actors in order to understand reality (Anti-positivism) and is focused on the subjective and unique experience of individuals (Idiographic). In comparison, design science research emphasises verifiable knowledge to a greater extent (Positivism) and also strives to establish "laws" or generalisations (Nomothetic). Action research is highly context dependent, focused on addressing the concerns of the specific client, and design science research does not assume any specific client or joint collaboration between researcher and client, though this is typically the case (ibid.). The similarities between design science research and action research are superficial and the two are conclusively different.

2.5.2 A Comment on the Breakthrough Method

When I explain my research to people in Swedish healthcare and at Sahlgrenska University Hospital involved in, or familiar with, development work I am often asked if I have used the Breakthrough method (*Genombrottsmetoden*). Therefore, I think it is reasonable to explain why I have not.

The Breakthrough method is a widespread method in Swedish healthcare for continuous improvement and was introduced in 1997 by the Swedish Association of Local Authorities and Regions (Swedish Association of Local Authorities and Regions, 2020b). The Breakthrough method is founded on the principle that those who perform work are the ones that can change work and is based on The Breakthrough Series. The Breakthrough Series is a collaborative model for improvement developed by the Institute for Healthcare Improvement, the model for which is shown in Figure 13 (Institute for Healthcare Improvement, 2004).

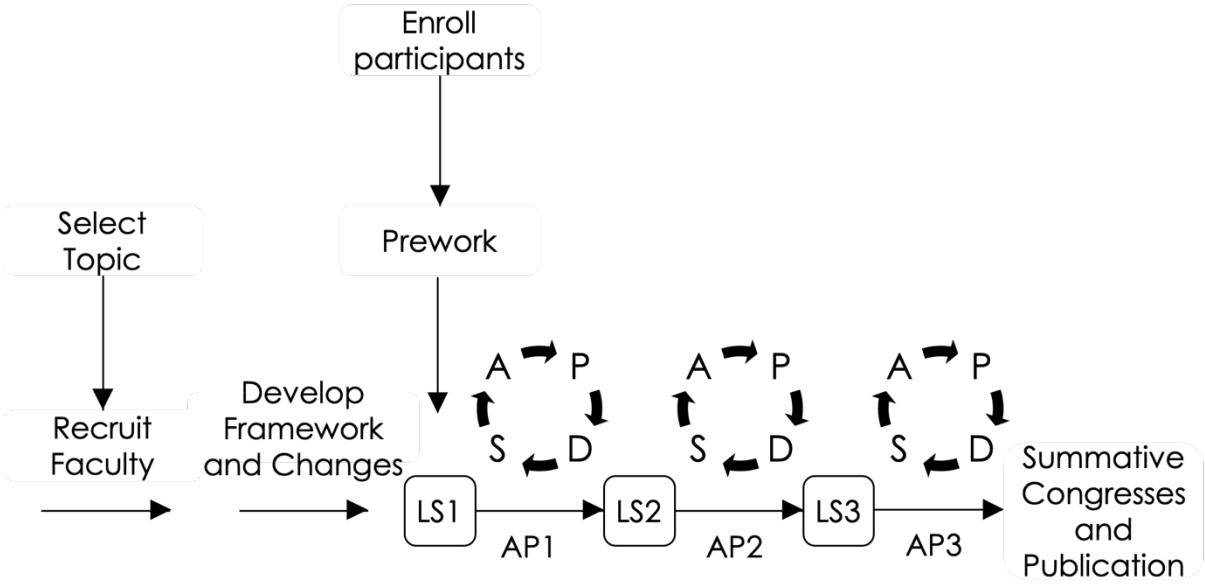


Figure 13. Institute for Healthcare Improvement Breakthrough Series model (Institute for Healthcare Improvement, 2004). LS: Learning Session, AP: Action Period, P-D-S-A: Plan-Do-Study-Act.

The Institute for Healthcare Improvement model involves a few initial steps of initiation followed by iterations of Learning Sessions and Action Periods, the basis for which is the Plan-Do-Study-Act (PDSA) cycle. The PDSA cycle on which the model takes inspiration from was developed for quality improvement by W. Edwards Deming (Holweg et al., 2018, p. 18). The Breakthrough

method is presented as more scaled down in comparison. It uses the same PDSA cycle and three fundamental questions: "What are we trying to accomplish?", "How will we know that a change is an improvement?", and "What changes can we make that will result in improvement?" (Swedish Association of Local Authorities and Regions, 2020b). The PDSA cycle outlines the work sequence to determine if a change is an improvement. The method presupposes that a problem can have different solutions based on the conditions in the context of which the problem is analysed. E.g. that a problem can be solved differently at different care units.

I have no objection to the Breakthrough Method, the Breakthrough Series model or the PDSA cycle as a work sequence for improvement initiatives. When I set out to do Healthcare Production Analysis Research I searched for modes of research that would be suitable. Since I was concerned with production, productivity, and efficiency I did not explore the field of Quality Improvement, where the PDSA cycle finds its home. Design science research shares a similar logic to that of PDSA and the Breakthrough Method. However, the Breakthrough Method's principle of 'Those who perform the work are the ones that can change the work' clashes a bit with my view that there are long-standing productivity and efficiency issues in healthcare that have not been solved by the healthcare professionals that carry out the work. I see an opportunity for industrial engineers and production engineers to contribute greatly to solving such issues in healthcare, despite not being the ones that carry out the work. Also, the Breakthrough Method's presupposition that a problem can have different solutions is also somewhat concerning for me in regards to the idea of standardisation as a foundation for efficiency improvement (or quality improvement for that matter). I am not averse to a problem having different solutions, but in terms of efficiency improvement it would be in the shape of a standard that is applicable in varying but similar contexts and results in different but similar solutions.

3 EMPIRICAL SETTING

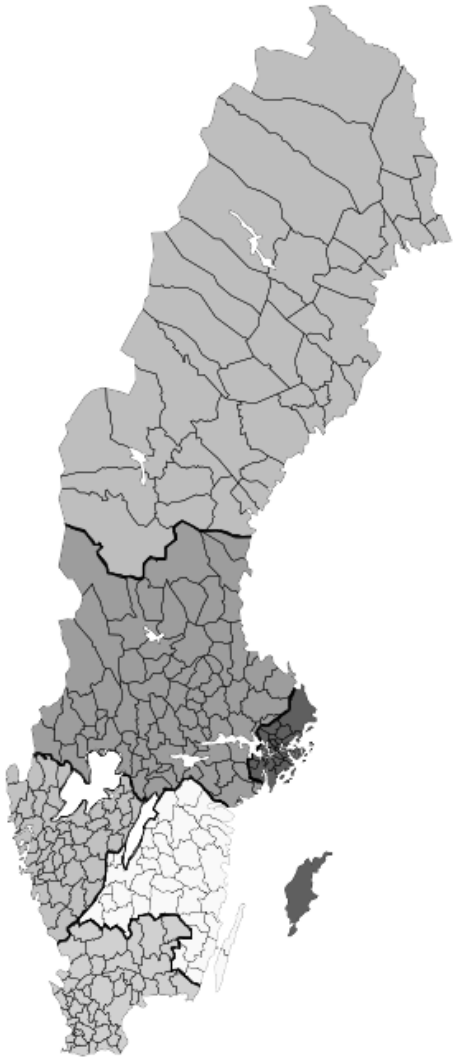
This chapter describes the empirical setting, the context, in which the research in this licentiate thesis has been conducted. Firstly, the organisation of Swedish healthcare at the national level is described. Then follow descriptions of how healthcare in Region Västra Götaland is organised, how Sahlgrenska University Hospital is organised, and how Production development is organised at Sahlgrenska University Hospital. A section on the role of the researcher concludes the chapter.

3.1 Public Healthcare in Sweden

Sweden is made up of 290 municipalities that are divided into 21 regions (Swedish Association of Local Authorities and Regions, 2020a). The Swedish healthcare system is organised following these three administrative levels: State, Regional and Municipal. How healthcare shall be organised and managed is regulated by Healthcare Law, SFS 2017:30 (Swedish Research Council, 2020). The role of the state is to establish principles and policy for Swedish Healthcare by laws or regulations, or by agreements with the Swedish Association of Local Authorities and Regions. It is the responsibility of the Ministry of Health and Social Affairs to fulfil the state's objectives in healthcare. Under the ministry is a number of administrative authorities that support the operations of the ministry, among them the Health and Social Care Inspectorate and the National Board of Health and Welfare (Government Offices of Sweden, 2020). The Health and Social Care Inspectorate is responsible for supervising healthcare so that it is provided in compliance with laws and other regulations and for handling reports of irregularities in healthcare (Swedish Health and Social Care Inspectorate, 2020). The National Board of Health and Welfare develops standards for health and medical services and patient safety based on legislation and maintain health data registers and official statistics (Swedish National Board of Health and Welfare, 2020a). The regions are responsible for organising healthcare in their respective region and the municipalities are responsible for support and service for people in their respective municipality who are discharged from hospital care (Swedish Research Council, 2020).

The healthcare tiers in Sweden are Primary care, County care (*länssjukvård)*, Collaboration-regional care (*regionsjukvård)*, and National specialised medical care (*Nationell högspecialiserad vård, tidigare rikssjukvård)* (Swedish Research Council, 2020). Primary care is the base of the healthcare system and is provided as outpatient care under the administration of a municipality. Primary care is responsible for basic medical treatment, care, preventive care and rehabilitation that does not require hospitals' medical or technological resources or other specific competence. If such is required, a referral is sent to a suitable specialist clinic. County care is the second tier of healthcare and is provided under the administration of a region. A region is the administrative body of a county, which is a geographic division. There are around 20 county hospitals (*länssjukhus)* and 40 county area hospitals (*länsdelssjukhus)* in Sweden. County hospitals have the capability to cover most disease areas. County area hospitals are smaller and do not always have all types of specialist clinics. A major part of hospitals' operations is inpatient care but they often provide outpatient care as well. The third tier of healthcare is collaboration-regional care. Sweden's 21 counties are divided into six collaboration-regions (*samverkansregioner, tidigare sjukvårdsregioner)* (SFS 2017:80, Chapter 3 § 1; Figure 14). Each collaboration-region contain at least one university hospital

(Swedish Research Council, 2020). Collaboration-regional care is provided by the university hospitals and all rare and complicated diseases and injuries are treated there.



Collaboration-regions, counties and municipalities	University hospital
UMEÅ Västernorrland county Jämtland county Västerbotten county Norrbotten county	University Hospital of Umeå
UPPSALA/ÖREBRO Uppsala county Södermanland county Värmland county Örebro county Västmanland county Dalarna county Gävleborg county	Uppsala University Hospital, University Hospital of Örebro
STOCKHOLM Stockholm county Gotland county	Karolinska University Hospital
GOTHENBURG Västra Götaland county Falkenberg municipality Kungsbacka municipality Varberg municipality	Sahlgrenska University Hospital
LINKÖPING Östergötland county Jönköping county Kalmar county	University Hospital of Linköping
LUND/MALMÖ Kronoberg county Blekinge county Skåne county Halmstad municipality Hylte municipality Laholms municipality	Skåne University Hospital

Figure 14. Collaboration-regions (from north to south): Umeå, Uppsala/Örebro, Stockholm, Göteborg, Linköping, and Lund/Malmö, and corresponding counties, municipalities and university hospitals.

National specialised medical care is the highest tier of public healthcare in Sweden and is provided at at most five locations in the country that can fulfil requirements of competence, accessibility and multidisciplinary teamwork (Swedish National Board of Health and Welfare, 2020b). The purpose of this concentration of specialised medical care to a few locations is to develop and improve knowledge, quality and patient safety for the rarest and most advanced medical care (SOU 2015:98).

3.2 Public Healthcare in Region Västra Götaland

Public healthcare in Region Västra Götaland is governed by a political organization of boards and committees (Region Västra Götaland, 2020). The Healthcare Board is the system owner responsible for coordinating healthcare in the region. The Healthcare Board coordinates the healthcare committees, which are the buyers of healthcare from the region's hospital, dental, and primary care boards (Figure 15).

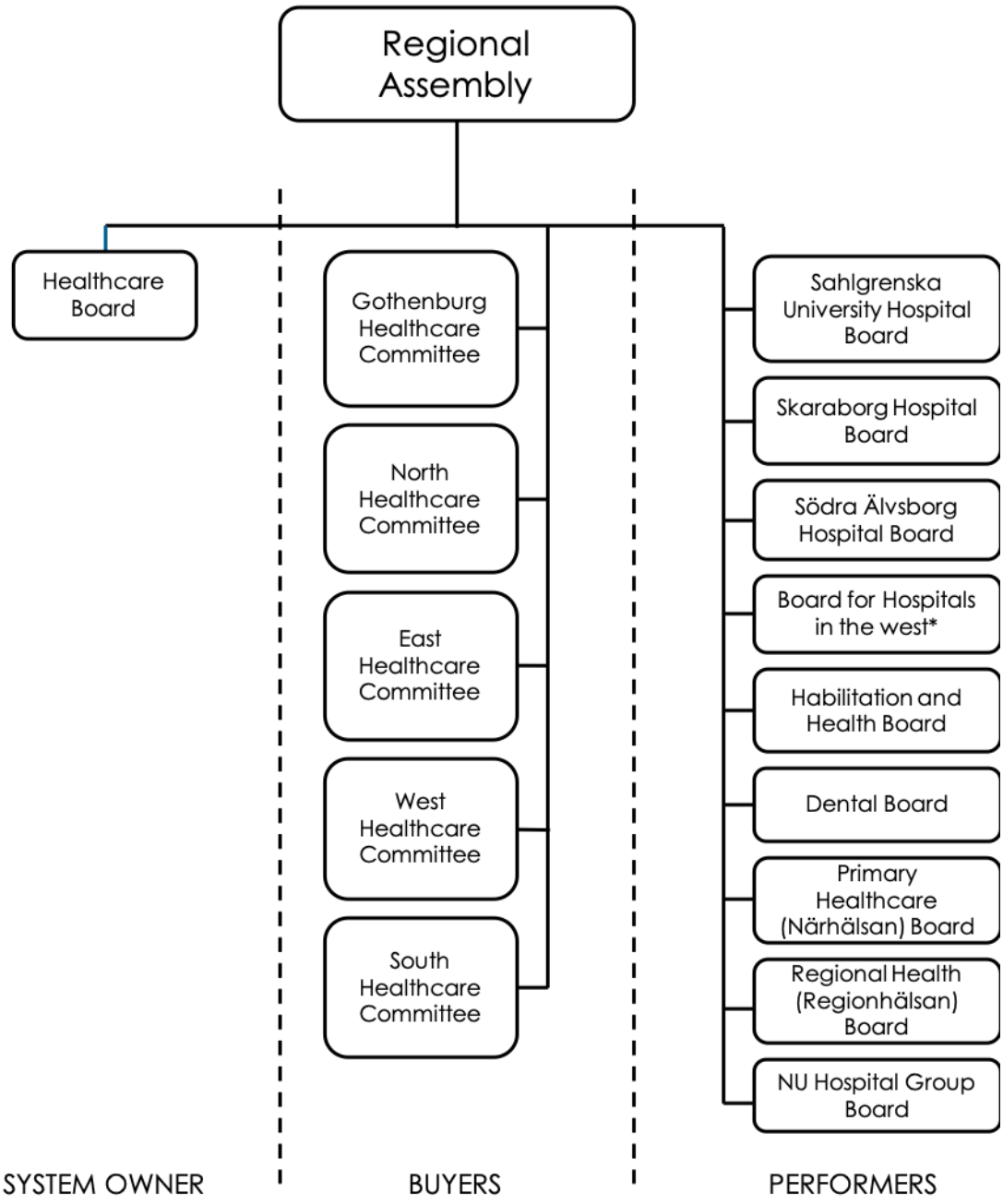


Figure 15. Organisation of Public Healthcare in Region Västra Götaland. (*Kungälv Hospital, Alingsås hospital, Angered Hospital and Frölunda Specialist Hospital)

The regional assembly of Region Västra Götaland allocates funds to the region's five healthcare committees, the North, South, East, West, and Gothenburg Healthcare Committees (Region Västra Götaland, 2020). Based on the needs of the population in their respective geographic area the healthcare committees order healthcare services from the boards of the region's hospitals and care centres, and if necessary other actors not owned by Region Västra Götaland. These are tasked with performing the healthcare that the committees have ordered.

3.3 Sahlgrenska University Hospital

Sahlgrenska University Hospital is a university hospital located in Gothenburg, Sweden (Sahlgrenska University Hospital, 2020a). The hospital provides emergency and basic care for the Gothenburg region and highly specialized care for the 1 700 000 inhabitants of the west of Sweden. Medical education and research is also conducted at the hospital. It provides County care, Collaboration-regional care and National specialised medical care. Sahlgrenska University Hospital is Sweden's centre for certain specialised care and has the joint most National specialised medical care assignments in Sweden: Craniofacial surgery, Heart surgery on adults, Heart transplantation, Liver transplantation, Lung transplantation, Paediatric glaucoma and cataract, and Paediatric heart surgery (Swedish National Board of Health and Welfare, 2020c).

The hospital has 52 departments, about 25 medical specialties, about 1 950 beds distributed over about 120 care units, and employs about 16 000 people (Sahlgrenska University Hospital, 2020a). Sahlgrenska University Hospital is located at multiple locations in Gothenburg: Sahlgrenska hospital, Östra hospital, Queen Silvia Paediatric hospital (*Drottning Silvias barn- och ungdomssjukhus*), Mölndal hospital (in Mölndal), Högsbo hospital and several outpatient clinics throughout the city.

Sahlgrenska University Hospital has a functional organisation structure primarily based on the medical specialties (Figure 16). It consists of the Sahlgrenska University Hospital Board, the hospital executive director (*Sjukhusdirektör*), the steering group, the executive director's staff, 'Common Administration', and six 'Areas' *(Områden)* under which the departments are organised (Sahlgrenska University Hospital, 2020b). The Areas are organised based on both medical specialty and geographical location and are each managed by an Area Manager (*Områdeschef*). The Area Managers answer directly to the hospital executive director and make up the hospital executive management group together with the executive director and a few of the executive director's staff.

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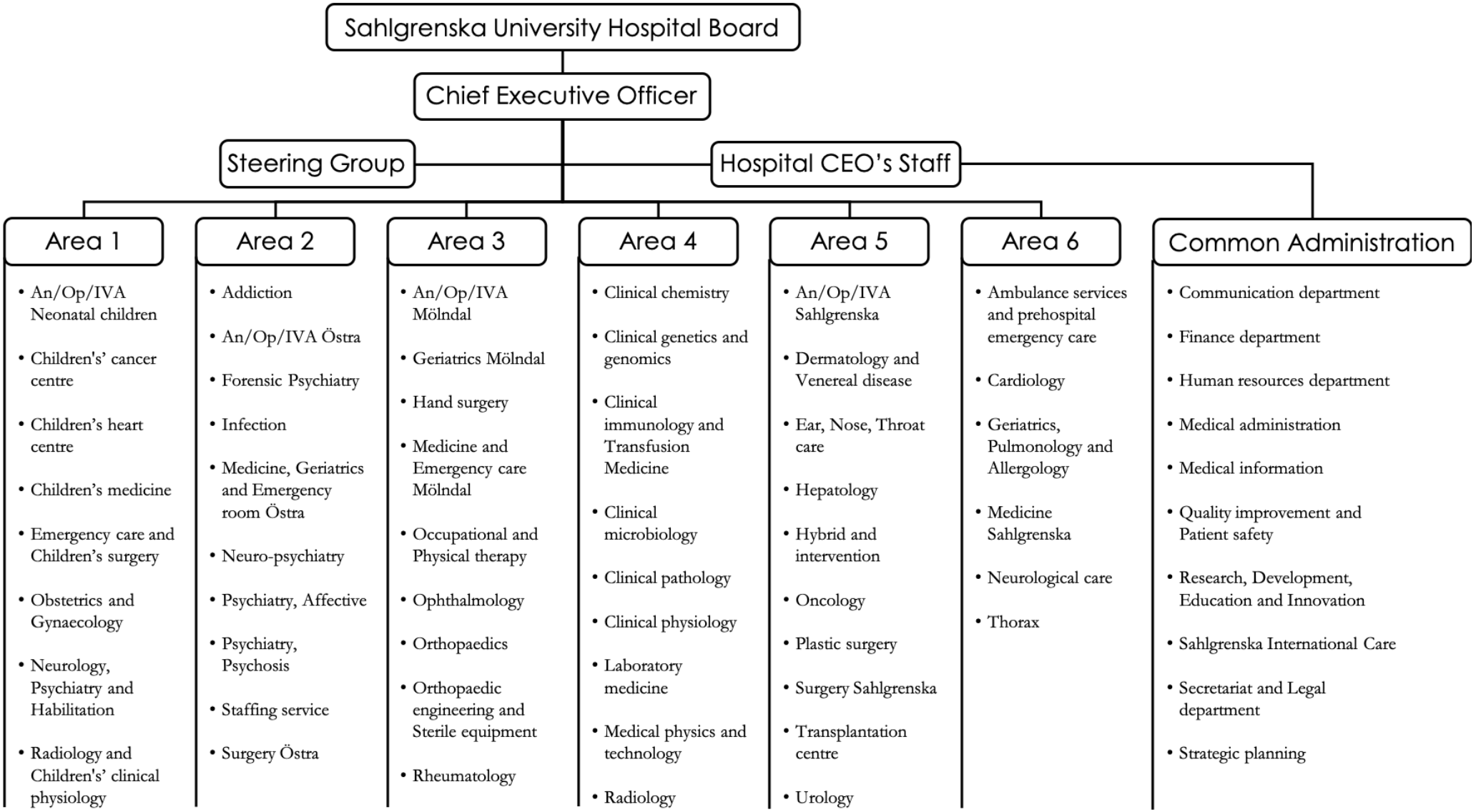

Figure 16. Organisation chart of Sahlgrenska University Hospital, and its departments. (An/Op/IVA = Anaesthesia, Operation and Intensive care)

Common Administration consists of different support functions that are either of a strategic nature and/or shared by the hospital (see Figure 16). In addition, the Areas also each have their own Communication, Finance, Human resources, and Quality improvement and Patient safety staff as part of their administrative management. To coordinate work across Common Administration and the Areas' administrations 'Function groups' (*funktionsgrupper*) have been established (Sahlgrenska University Hospital, 2020b). There are five Function groups: Communication, Finance, Human resources, Quality and Patient safety, and Digital health that have hospital-wide responsibility for coordinating work in their respective area. They are made up of the corresponding function's hospital director and the managers of the function at the different hospital Areas.

Sahlgrenska University Hospital also has Centres of Excellence to facilitate cooperation across organisation boundaries for patients that require care from different medical specialties (Sahlgrenska University Hospital, 2020a). The centres entail a continuous care chain where medical professionals from different medical specialties work together in multidisciplinary teams. Currently there are twelve Centres of Excellence: Breast Cancer Centre, Cystic Fibrosis Centre, Centre for Advanced Reconstruction of Extremities, Centre for Huntington's Disease, Centre for Specialised Epilepsy Care, Centre for Medical Genomics, Centre for Rare Diseases, Chronic Obstructive Pulmonary Disease Centre, Geriatric Development Centre, Intestinal Failure Centre, Prostate Cancer Centre, and Transplantation Centre.

In comparison to the traditional way of organising hospitals based on medical specialties a different way of organising care based on patients' pathways has emerged in recent years. E.g. Karolinska University Hospital in Stockholm is organised based on Medical Theme Areas as well as functions (Karolinska University Hospital, 2020). The themes are Aging; Cancer; Children and Women's Health; Heart and Vascular; Inflammation and Infection; Neuro; and Trauma and Reparative Medicine. The functions are Allied Health Professionals; Emergency Medicine, Laboratory; Perioperative Medicine and Intensive Care; and Radiology and Imaging.

3.4 Production Development at Sahlgrenska University Hospital

To develop the operations of the hospital is the responsibility of each Area, department and unit and their corresponding managers, as well as the hospital CEO and steering group. So-called line responsibility. The responsibility includes ensuring and improving e.g. quality of care, patient safety, work environment, economy, efficiency, and productivity. In regards to production, Sahlgrenska University Hospital have a Director of Operations who is part of the steering group and is responsible for promoting initiatives that benefit production. Furthermore, the responsibility for production development also crosses the domains of a number of Function groups. Primarily the groups for Quality improvement and Patient

safety, Human resources, and Finance. The general responsibility of the Function groups includes to coordinate and make common work processes for planning and follow-up more efficient, to act for standardisation and common solutions, and to draw up policies, guidelines, and routines (Sahlgrenska University Hospital, 2006). The groups also have specific responsibilities: The Function group for Quality Improvement and Patient safety is responsible for formulating proposals for strategy and implementation plan for quality improvement and business development, the Function group for Human Resources is responsible for processing matters of great personnel-political and economic importance, and the Function group for Finance is responsible for processing matters with great economic consequence. Production and production development falls partly in the domain of all these areas: quality improvement, business development, personnel, and economy. The Function group for Quality improvement and patient safety, which is responsible for business development, is chaired by the first chief medical officer and includes the Development managers of the different Areas. The Development managers have a number of different staff working for them, which varies between the Areas e.g. Coordinators of different types: Quality, IT, Security, and Environment; Facilities planners; Project managers; and Operations developers (see Figure 17). Although typically, Operations developers are employed at the Department level and work for the Department managers.

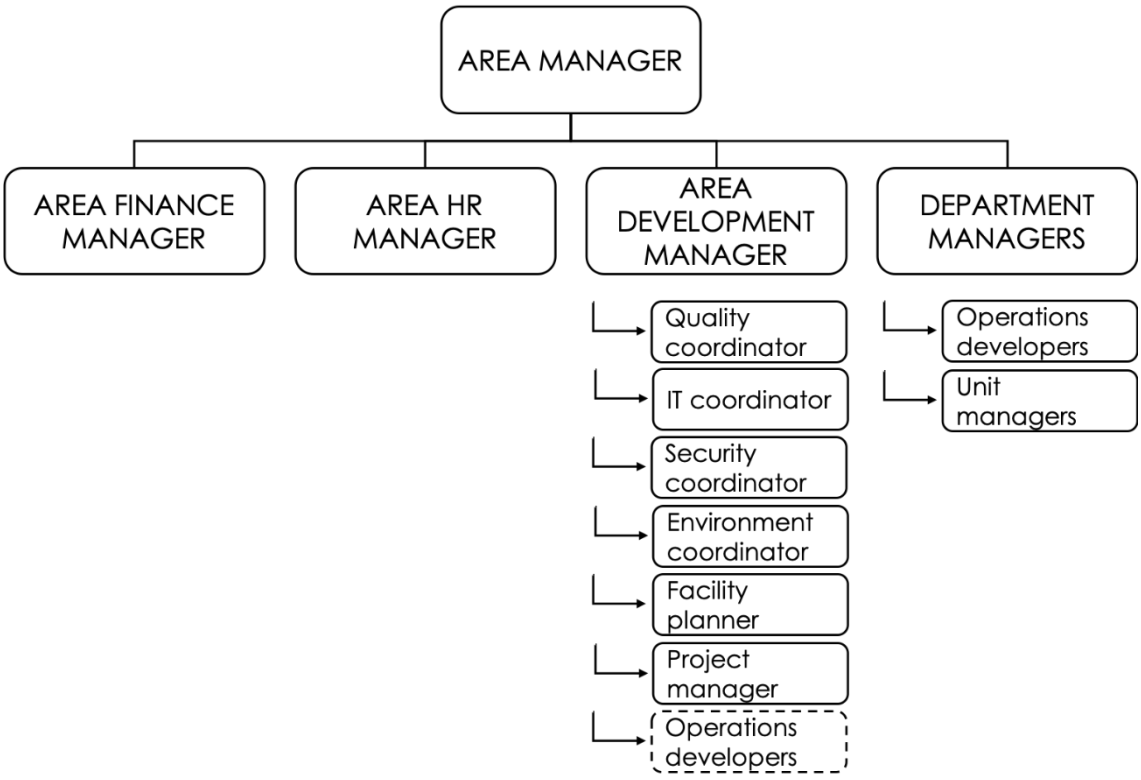

Figure 17. Organisational positions in development work at Area level

In Common Administration there is also an Analysis and Project unit which is a support function for the hospital that is involved with project management, project support and data analysis . One of the three sub-groups, called the Logistics and Analysis group, provides support in production-related activities and improvement initiatives. Primarily at department level, but also ranging from unit level to regional level. Some hospital-wide initiatives that have had their main project support and expertise from this group are e.g.: Production planning, Lean healthcare, and Value-based healthcare.

3.5 Role of the Researcher

Since the beginning of the doctoral project the researcher has also been employed at Sahlgrenska University Hospital. In the summer of 2015 the researcher was enrolled at the Division of Operations Management (later the Division of Supply and Operations Management) at the Department of Technology Management and Economics at Chalmers University of Technology. At the same time the researcher also started a position as Care Unit Development Manager at 'the Care Ward of the Future' (*Framtidens vårdavdelning*), spending the time equally between the two vocations. The Care Ward of the Future was a development project started in 2014 initiated by the Area Manager of Area 2, the HR director and the Research, Development, Education, and Innovation director. The project and ran as a care unit at Östra hospital between 2015 and 2018. The aim of the project was to develop sustainable and effective care, to increase the patient-perceived quality, and to accomplish a cost-effective operation with good work environment. In 2017 the assignment was made permanent at the department where the care unit was located and later moved to another of the care units there. Between August 2015 and August 2017 the researcher was responsible for coordinating and facilitating development groups made up of the staff at the care ward. This included project management and development work facilitation, observing everyday work and situations, problematizing, brainstorming solutions, analysing, testing, measuring, implementing, and reviewing. Based on the aim of the project the development groups came up with different initiatives and suggestions for developing the work organisation at the care ward and the department. This included e.g.:

- Dividing work based on responsibilities and work tasks instead of dividing patients for both registered and assistant nurses.
- Shifting work tasks from registered nurses to assistant nurses.
- Shifting work tasks from assistant nurses to a ward host/hostess, namely ordering materials, restocking supply, taking patients' orders for meals, and ordering and distributing meals.
- Coordinated Patient Care Planning (*Samordnad vårdplanering*) by assistant nurses instead of registered nurses.
- Including medical secretary, pharmacist, and assistant nurse in ward rounds.

- Prioritising which patients to visit during the rounds, i.e. the patients that required rounding and not rounding all patients without considering the need for a patient to be rounded.
- Recruiting a prescriptionist to prepare medications to ease some of the workload of the registered nurses.
- Having the role of care unit coordinator being fulfilled by assistant nurses instead of registered nurses, e.g. answering the phone, handling patient registration and discharge.
- Having the medication part of the Care and medication account (Epicrisis, *Vård- och läkemedelsberättelse*) being written by an pharmacist instead of a doctor.

In August 2017 the researcher moved to the Logistics and Analysis group at the Analysis and Project unit (see 3.5). This involved no longer managing the development groups at the Care Ward of the Future (or elsewhere) and instead working either in more temporary project groups, where the researchers competences were required, or more independently on projects such as the ones presented in this licentiate thesis. The temporary groups typically consisted of, and were managed by, people from different parts of Sahlgrenska University Hospital and/or Region Västra Götaland and the more independent work involved projects that were usually headed by one of the Project Managers at the Analysis and Project unit. Since February 2020 to the publishing of this licentiate thesis the researcher has been focusing only on doctoral studies.

4 RESEARCH METHODOLOGY

This chapter first recounts three pre-studies at the Care Ward of the Future: a work sampling study, a master student project on medication work, and a relocation of medications and materials in the medication room. These preceded and inspired the research projects 'Standard for Medication Work in Care Units' and 'Systematic Work Activity Mapping'. The research design for these two research projects are then described after an introductory section on the research design outline.

4.1 Pre-studies at the Care Ward of the Future

This section explains research activities that preceded, and served as pre-studies for, the projects Standard for Medication Work in Care Units and Systematic Work Activity Mapping.

4.1.1 Work Sampling Study

The first research activity preceding the project was a work sampling study. The purpose of using work sampling at the Care Ward of the Future was to get a distribution of work activities performed by the registered and assistant nurses at the ward (Table 11). At 30-second intervals an observation of nurse activity was made by a nurse trained in categorising and recording activities using a tablet and work sampling software. The study was made according to a schedule to cover all days of the week and all hours of the day. The study covered 100 hours of observation and was conducted during the spring of 2015.

Table 11. Distribution of registered and assistant nurse activities at the Care Ward of the Future

CARE WARD ACTIVITIES	Share of registered nurse activities	Share of assistant nurse activities
1. DIRECT PATIENT WORK	**34.6%**	**30.6%**
1.1 Examine patient	5.5%	4.1%
1.2 Treat patient	9.7%	4.9%
1.3 Handle and assist patient	14.7%	17.7%
1.4 Move patient	0.0%	0.3%
1.5 Talk with patient	4.7%	3.6%
2. INDIRECT PATIENT WORK	**41.1%**	**26.7%**
2.1 Talk about patient (face-to-face)	11.9%	9.7%
2.2 Talk about patient by telephone	1.5%	0.5%
2.3 Document and read information about patient (in writing, on computer)	14.1%	9.6%
2.4 Dispense medications	12.7%	3.5%
2.5 Serve food	0.1%	1.8%
2.6 Collect and leave materials, test samples and equipment pertaining to a particular patient	0.8%	1.6%
3. SERVICE WORK	**5.4%**	**9.7%**
3.1 Other handling of medications, materials and equipment	3.3%	0.8%
3.2 Cleaning up and putting into order	1.3%	6.4%
3.3 Prepare meal	0.1%	1.3%
3.4 Administration and information management not pertaining to patient	0.7%	1.3%
4. MISCELLANEOUS ACTIVITIES	**18.9%**	**33.0%**
4.1 Search for materials and equipment	0.1%	0.1%
4.2 Look for someone	0.1%	0.1%
4.3 Search for information	0.2%	0.4%
4.4 Handling, or being delayed by, an IT disruption	0.2%	0.1%
4.5 Manage other disruption	0.5%	0.2%
4.6 Waiting and personal time	17.8%	32.2%
4.7 Own movement	0.0%	0.0%
NUMBER OF OBSERVATIONS	**8306**	**6701**

In 34.6% of the observations registered nurses were doing activities directly involving the patient, direct patient work. In the majority of the observations patients were not directly involved and indirect patient work constituted 41.1% of registered nurse work. This work is pertaining to patients, but not directly involving them. For assistant nurses the share is 30.6% direct patient work and 26.7% indirect patient work. Based on this work sampling study the idea to look into pharmaceutical preparation originated. The indirect patient work activity

'Dispense medications' was measured to take up 12.7% of registered nurse time and comprised both preparing medication and distributing medication to patients. Since it was a well-delimited activity and made up such a large share of registered nurse time it made 'Dispense medications' a prime candidate for work method improvement.

4.1.2 Master's Student Project on Medication Work

During the late fall of 2015 a group of students, in the course 'Industry Project' in the Production Engineering Master's Programme, were tasked with investigating how the medication work at the Care Ward of the Future could be made more efficient (See Appended Paper 1). Many thanks to Erik Bernérus, Jennie Boérius, Arnór Jónsson, and Natalie Zanganeh. The group was supervised by Peter Almström, associate professor at Chalmers University of Technology, and by the author in the role of care unit development manager at the Care Ward of the Future. The idea for the student project came from the results of the work sampling study presented above. As one of the largest work activities and the largest cohesive work activity 'Dispensing medications' was a good candidate for being made more efficient. The group found that the layout of the medication room and the design of the medication cart did not support the registered nurses well in their work. The nurses spent a lot of time walking around in the room looking for medications and materials. Registered nurses have the competence and education needed to prepare medications but lack the competence to design and plan a work area from an engineering perspective. Hence, it is necessary with engineering competence to design work areas that are designed to promote productivity and good ergonomics.

4.1.3 Relocation of Medications and Materials in the Medication Room

Based on the results of the master student project, the author proposed to the Project Manager of the Care Ward of the Future to redesign and re-furnish the medication room at the unit. A complete redesign was rejected partly due to lack of budget for such an undertaking and partly due to the medication room having been renovated recently. The medication room was renovated in 2014 prior to the care unit opening and the suggestion to remodel based on master student project results was proposed in late 2016. Instead it was decided to try to address the shortcomings of the current layout and come as close as possible to the ideal design with existing furnishings. The author together with the pharmacist and the three registered nurses responsible for the medication room were tasked with doing this.

The pharmacist obtained a list of medications ordered to the care unit during the previous 12 months which were sorted from the highest to lowest amount of doses ordered. The list of ordered medications was used since data on medications actually prepared and administered to patients did only exist on a patient-by-patient basis. This list of the most common medications served as a guide for which medications to be prioritised to account for when making changes. Based on the list of medications the three nurses, assisted by the author, complemented the list with the general method for preparation of each pharmaceutical, including materials used in preparation. A general work flow was also

established: 1) read ordination, 2) collect pharmaceutical and materials, 3) prepare pharmaceutical, 4) label the pharmaceutical with information: patient identification etc., 5) throw away the waste generated, 6) store prepared pharmaceutical, 7) repeat until all medications have been prepared for all patients. The layout of the medication room greatly affected the performance of each step in the workflow, e.g. distance travelled, numbers of drawers opened, and reaches above shoulder and bends below knees.

The information on how commonly different medications were (in terms of amount ordered, inferring amount prepared and administered) and which materials were used in their preparation resulted in several changes in what medications and materials were placed. Two main groups of medications were identified: Easy-to-pick medications such as tablets and similar, and Fluid medications, administered through injection or infusion. Fluid medications had a lot more materials related to their preparation which were often used in combination and were directly related to how to prepare a certain type of fluid pharmaceutical. Infusion containers, to which fluid medications are sometimes added, were concentrated to one location, an infusion container cart. The medication cart, used for storing prepared medications in patient-specific drawers and held a computer to access the medical system, was repositioned into the centre of the room instead of by the entrance in the corner of the room. Fluid medications were concentrated to one location, close by the sink. Easy-to-pick medications remained placed on the shelves over the counters running along the walls of the room. Both types of medications were kept organised according to Anatomic Therapeutic Chemical classification conforming to hospital regulation. The contents of the drawers under the counter were set based on if they were related to preparing infusions and other fluid medications or not. Materials used together were placed in the same drawers and more frequently used materials were placed more accessible than less frequently used materials, e.g. less used materials in lower drawers. The frequency of use of materials was based on the pharmaceutical order statistics of the care unit from the hospital pharmacy. The drawers on the medication cart were also rearranged. The drawers containing medications shared by multiple patients were placed at the top of the cart and the drawers containing patient specific medications (one drawer per patient) were placed further down. This change was made because registered nurses had to open the shared drawers more times than the patient specific drawers when preparing and administering medications resulting in more instances of bending down or reaching far than when drawers were placed as after the change.

4.2 Research Design Outline

Research design is the plan of which methods and procedures to use to collect and analyse data to reach research objectives. The research design in this licentiate thesis is presented according to the following procedure of setting a research design adapted by Holmén (2013) from Bryman & Bell (2011, pp. 150-153):

1. Define research topic
2. Define general objective and research type
3. Determine specific research objective and research type
4. Choose the research design(s)
5. Select instances
6. Conduct 'measurements'
7. Conduct data analysis
8. Discuss results
9. Report the results

The procedure has been adapted so as to be fitting for research in general and not specifically for quantitative research. Defining the research topic (1.) depends on the nature of the problem. E.g. is the research to help solve a problem, to say how something is, or to say how something should be? To define the general objective and research type (2.) depends on if the nature of the (intended) outcome of the research is theory-oriented or practice-oriented. If the research is to identify, richly describe, and/or create a more general explanation or prediction it is theory-oriented. If it is to identify and/or implement a potential solution and/or solve a specific problem for a particular actor it is practice-oriented. Determining the specific research objective and research type (3.) depends on what is known. Practice-oriented research can be Descriptive, Hypothesis-building, or Hypothesis-testing. Descriptive research is empirical study to identify hypotheses and can be a precursor to hypothesis-building, which in turn is studies of literature (and practice) to find hypotheses. Hypothesis-testing is self-explanatory and can be done by e.g. implementation of a solution. Theory-oriented research can be Explorative, Theory-building, or Theory-testing. Explorative research is to assess how empirical research can contribute to theory development by collecting evaluating information. Theory-building is to devise new propositions from evidence of a phenomenon. Theory-testing is to test such propositions. To choose the research design (4.) depends on the prior steps and is to establish a framework for collecting and analysing data by employing choosing the type of study, e.g. an experimental study or a case study. Selecting instances (5.) is to decide on collecting data from one, a few, or many instances, as well as where and when to measure. To Conduct measurements (6.) what research methods to use needs to be decided, as well as how and why they are used. Examples are e.g. interviews or observing behaviour. Conducting data analysis (7.) is done by either visual inspection or statistics. Visual inspection involves high richness per instance and statistics involve a high number of data points per instance. If the

research is theory-oriented or practice-oriented, discussing results (8.) involves discussing the implications for theory and practice respectively. The same goes for reporting the results (9.) towards experts and researchers, or towards practitioners respectively.

4.2.1 Standard for Medication Work in Care Units Project Research Design

The project 'Standard for Medication Work in Care Units' (the Pharmaceutical work project) was initiated as a continuation of the pre-studies presented in Section 4.1. The Work sampling study revealed that time spent by Registered and Assistant nurses on direct patient work activities was in the minority compared to other work activities. Time spent on direct patient work activities (Examine patient, Treat patient, Handle and assist patient, Move patient, and Talk with patient) is primarily value-adding time. In contrast, time spent on indirect patient work activities, Service work activities, and Miscellaneous activities is primarily non-value-adding time (from the perspective of the patient), but their performance often enable value adding activities to be carried out. The Master student project on pharmaceutical work showed that the pharmaceutical preparation work activity was performed in an inefficient manner in regards to unnecessary elements in the work method and that the work area did not support working in an efficient manner. Relocation of medications and materials in the medication room at the Care Ward of the Future was done based on the learnings from the Master student project and showed that the work area in the medication room could be improved in practice.

The research topic for the Pharmaceutical work project then was to investigate how the pharmaceutical preparation work could be made more efficient. The research would ideally result in a deliverable that would be a way of making pharmaceutical work more efficient, helping to reduce the time spent on that (non-value-adding) indirect patient work activity. Thus:

The aim of the Pharmaceutical work research project is to provide a solution for how pharmaceutical work is to be performed more efficiently.

Since the research addresses a problem in reality marks it as practice-oriented. More specifically, hypothesis-testing since the project mainly strived to test the hypothesis that the pharmaceutical work was inefficient due to a lack of a standardised and efficient work method and therefore took up more time than it could or should. Thus:

The research question of the Pharmaceutical work research project is: How should pharmaceutical work at a hospital care unit be improved to become more efficient?

The research is also partly theory-testing, since methods used to improve work methods have not been extensively used in healthcare, at least from what has been ascertained by the author (see Section 2.1.1). As the research focused on solving a problem and was both practice- and theory-oriented design science research was identified as a suitable part of the research design framework (see Section 2.5). To reiterate, the idea of design science research is to understand

a problem, create a solution to the problem, evaluate the solution, and enable an improved situation, as well as bridging the gap between theory and practice. The Problem Solving Cycle served as the overarching procedure for conducting the research (see Section 2.5). Since the research also concerned a phenomenon in its empirical context where the boundary between the context and the phenomenon was not clear a case study delimitation was natural. Selecting instances based on this was logically to start small with one instance and expand to a few instances. Being a design science research case study, including qualitative research elements, access was paramount. Since access was already established through the employment of the author at the Care Ward of the Future it followed that there was a suitable place to start conducting the research. Further instances would be initiated later in the project, also based primarily on access. Several research methods were employed to conduct measurements. Pharmaceutical work was observed by the author and video recorded on a number of occasions. MTM-SAM was used as basis for what constitutes efficient work as well as to evaluate the efficiency of work in combination with the 'MPU' productivity factors (see Section 2.3.1 for both). Furthermore, talks and email correspondence with personnel at the hospital (e.g. registered nurses, prescriptionists, and pharmacists at the hospital pharmacy) was used to define the problem and the solution space, as well as test propositions and ideas. Workshops with personnel were used for the same purpose. Different types of written material and documents were also used to understand laws, rules, regulations, quality criteria, routines that could not be diverted from or changed that also set limitations and delimitations to the solution and shaped the problem. Conducting data analysis was done parallel with data collection due to the iterative nature of design science research, redefining the problem when new limitations were introduced, and re-evaluating the solution. Data analysis was conducted based on the above, as well as a MTM-SAM analysis, and a questionnaire to registered nurses at a care unit where the solution had been implemented.

4.2.2 Systematic Work Activity Mapping Project Research Design

Some of the work activities that made up the activity list for the work sampling pre-study were described on a relatively general level, e.g. Examine patient or Treat patient. The list of activities is generic in terms of suitability for sampling work at care units regardless of speciality, but it also provides a generic description of work. To be able to describe work in more detail the description of work activities need to be more detailed and specific. Identifying and delimiting specific work activities is also necessary in order to be able to describe and make improvements to them (see Section 2.4). A hospital project was initiated with which the Systematic Work Activity Mapping research project (the Mapping Project) was intertwined. The goal of the hospital project was to identify the work activities carried out at care units at Sahlgrenska University Hospital. The research topic of the research project was to help solve the problem of identifying these activities. Thus:

The aim of the Systematic Work Activity Mapping research project was to provide a solution for how to identify work activities carried out at care units.

Since the research strived to provide a solution for a specific problem defines it as practice-oriented. Additionally, the research would also produce an extensive census of work activities, providing a description or prediction of which work activities are performed at care units (of different specialities). Hence, the research is both hypothesis-building and descriptive since by solving the field problem of identifying activities it will generate a method of doing this as well as information on a body of work activities, i.e. which work activities are carried out at care units at a large public university hospital that provides medical care from basic to highly specialised. Thus:

The research question of the Systematic Work Activity Mapping project is: How should work activities in hospital care units be systematically identified, collected, and organised?

As the research focused on solving a problem (solving a design problem to solve a field problem) design science research was chosen as the overarching methodology of how to conduct the research. Since the object of study was a contemporary phenomenon in its empirical context, a case study approach was also chosen. Since the aim was to solve how to identify work activities from a multitude of care units the number of instances needed to be many to provide saturation of identified work activities. Additionally, care units of different specialities was hypothesised to vary in what work activities they carried out. Therefore care units were not sampled randomly but instead approached based on the type of medical care they provided. The research methods used to conduct measurements were primarily focus groups. The hospital project group constituted a recurring focus group that progressed and shaped the solution and result and personnel at care units constituted one-time focus groups. The latter were attended by individuals from the recurring focus group as facilitators which also brought back data to be processed in the hospital project group. Pre-existing work activity lists from the work sampling study and hospital human resource projects were used as a starting point. To guide data analysis, the definition of 'activity' (see Section 2.1.1) provided an outline. To reiterate, an activity has a purpose and an objective and is described in verb form. An activity consists of one or more sub-activities which in turn consist of elements. When data on work activities was gathered in the care unit personnel focus groups it was brought and discussed in the hospital project focus group. There new data on work activities was evaluated if it was a new work activity or related to an already identified work activity. If it was new it was discussed how it should be formulated. If it related to an identified work activity it was evaluated if a change in the formulation of an existing work activity was warranted, if the new data warranted a sub-activity to an existing work activity, or if it warranted the creation of variants to an existing activity. Data could also not warrant any new identified work activities and just repeat data already collected from other care unit personnel focus groups.

5 RESULTS

One of the benefits of writing a licentiate thesis is the opportunity to expand on different aspects of the conducted research. This licentiate thesis elaborates on the design science research aspect of the Standard for Medication Work in Care Units and Systematic Work Activity Mapping projects. The appended papers provide a condensed description of the design science research process where the end product of the research is more in focus. This chapter describes the design science research aspects in more detail than the appended papers are able to.

5.1 Standard for Medication Work in Care Units Project Results

This section presents the results of the Standard for Medication Work in Care Units project. A chronological extensive account is provided in Appendix II. The identity of care units have been anonymised and individuals are referred to by their work title except for a few exceptions. First a summarised account is presented followed by accounts of three workshops. Thereafter, three sections describe principles for designing the medication room, furnishings in the medication room, and placement and prioritisation of furnishings. These are excerpts from the Pharmaceutical work project standard document 'Standard for Medication Work in Care Units'.

The Master's student project (see Section 4.1.2) showed that the current design of the pharmaceutical storage room and the medication cart did not support the personnel in their work. Based on the learnings, changes to the medication room were made (see Section 4.1.3). To proceed with realising ideas on more efficient work methods for pharmaceutical work for the whole hospital initiating a development project at the hospital was suggested to the hospital executive director and approved. A project group was established consisting of the author, Peter Almström as strategic advisor to the hospital executive group, a project manager, a logistician from the Analysis and project unit, a prescriptionist at Östra hospital, and the registered nurse responsible for medications at the Care Ward of the Future.

The first step was to meet with the Sahlgrenska University Hospital hospital pharmacy manager to establish the initiative. Particularly how to proceed in relation to the introduction of *Slutenvårdsdos* (SVD-medications) at Sahlgrenska University Hospital. SVD-medications are delivered to care units as a rolls of pre-packaged patient-specific plastic pouches each one containing the patient-specific dose of one pharmaceutical for one administration period, i.e. each patient could have a number of pouches per administration period for several periods per day. The regional pharmacy manager had previously stated that the Region Västra Götaland hospital pharmacy did not have any assignment to intervene with how work areas were designed in hospital's medication rooms. The author and Peter Almström met with the hospital pharmaceutical operations manager, the hospital pharmacy manager, and the regional hospital pharmacy manager which led to the Pharmaceutical Operations Unit

providing support to produce more efficient work methods. The pharmaceutical operations manager is positive but does not think it is possible to align the project with the implementation of SVD-medications. The author and the project logistician attend implementation of SVD-medications project meetings throughout the spring of 2018 to identify what the implementation would imply for pharmaceutical work at care units and identify touch points with the Pharmaceutical standards project.

The scope of the project was delimited to the work carried out in the medication room. With regards to SVD-medications: how to receive, store, prepare, and handle waste. In general: when patient information, person information, and pharmaceutical information for handover is necessary and to what extent. Additionally, other aspects needed to be considered: storage of prepared medications, division and sorting of medications delivered to the care unit, transport of medications to the patient, design of the work area to serve a combination of needs: infusions, injections, simple medications, and common medications. An initial workshop was held to discuss a significant number of details regarding preparations of medications and the work area for it (see Section 5.1.1)

The author and the project followed the project prescriptionist along for a day's work to observe the practical work in the entire pharmaceutical work flow. From receiving a delivery of medications, packing up, preparing medication, any temporary storage of prepared medications, preparing transport of medications to patients, to ordering medications. The project logistician formulated summarising points on routines for pharmaceutical preparation such as labelling and control, single dose systems, practical work with infusion fluids and antibiotics, dispensing of medications for later use, allergy risks etc. Region Västra Götaland's guidelines for handling and preparing medication specifies certain work elements focusing on quality, safety, and medical integrity. Rules, regulations, and routines are established at different levels. At the national level by e.g. the Swedish Association of Local Authorities and Regions, the Swedish National Board of Health and Welfare, and the Swedish Medical Products Agency. At the regional level, at the hospital level, at the department, and at the unit level. Routines are commonly created locally at the department or care unit level because an overarching routine is not specific enough to regulate the circumstances at the lower level. Some overarching routines can also be deviated from to some degree by creating a local routine where a unit or department manager takes responsibility for consequences arising from deviating from the overarching routine to adapt to the local context.

Another Master thesis project in Production Engineering was initiated to map medication rooms at hospitals in Region Västra Götaland and investigate the preconditions for standardising them. The medication rooms mapped differed in their configuration with regards to size and placement of doors and windows (H. Sundström, 2017). The rooms contained similar furnishings: sinks, shelves, and countertops but these differed in configuration, e.g. how much shelf space and countertop area there was as well as the placement of furnishings in the rooms. Based on information from the Master thesis,

Workshop 1, and observations of the pharmaceutical work flow the author and Peter Almström created an ideal generic layout of a 3 x 4 m medication room, a regular size according to the medication room mapping. The layout is shown in Figure 18.

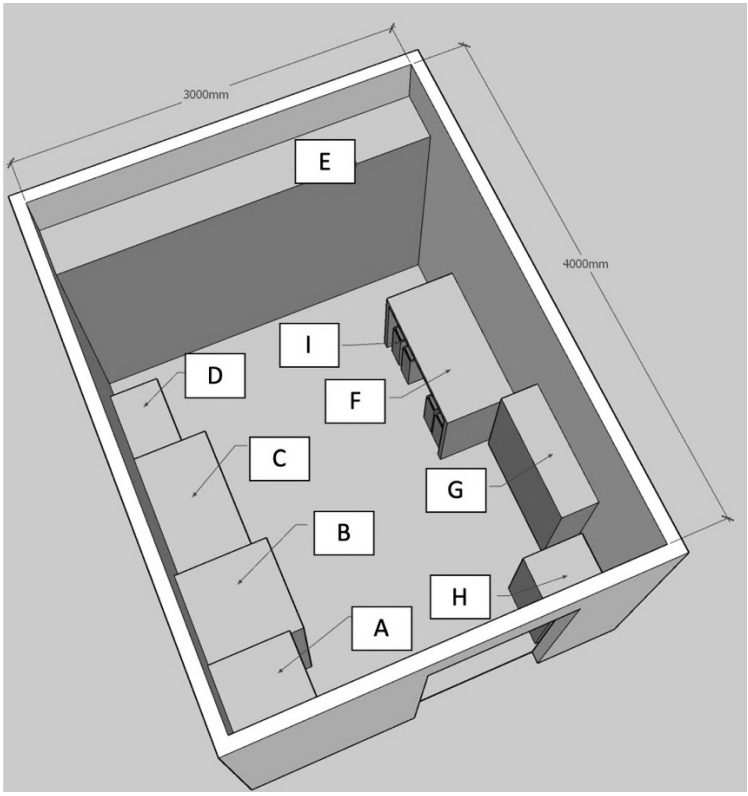

Figure 18. Ideal medication room layout.

The door was placed in the middle of the wall on a short end. Along the left wall from the point of view of the entrance the following were placed in order from left to right: A) refrigerator, B) infusion container cart, C) a work station for injections and infusions, and D) a sink. Along the whole back wall E) shelves for storing medications and general storage was placed. Along the right wall (from left to right): F) work station for pills and other simply prepared medications, G) kit storage for prepared medications, and H) a medication cart. I) Waste bins of different fractions were placed under the work station countertops. A prototype of a shelf for quickly picking the most commonly prepared medications at a care unit was also sketched. The point of the quick-pick shelf was to minimise the need to move away from the work station to collect medications. The shelf consisted of three sections of shelves arranged in a semi-circle on at 45 degree tilt in reference to the work station countertop. A second workshop was held to test a prototype of a work station for injections and infusions, to test a prototype of a work station for solid and quick-pick medications, and to test a prototype of a kit storage (see Section 5.1.2).

The author also followed along a registered nurse for an evening shift at a care unit at the Sahlgrenska hospital main building. At the care unit the pharmaceutical preparation work

was performed mainly at medication carts in the nurses reception. As a result nurses were often interrupted by other work. According to a hospital evaluation at another care unit of pharmacists and prescriptionists in patient care medication carts did not fit in that care unit's medication room and as a result had to be placed in the corridor or the nurse reception where nurses could not work undisturbed. Thus, more time was spent handling, preparing, and administering medications than necessary and a lot of walking between the medication carts and the medication room was required since the carts did not contain all necessary medications for patients. The typical design of traditional medication carts is a chest of drawers on wheels with a countertop for preparing and labelling medications, a holder on the back for infusion containers, and some waste bins for different types of waste, e.g. syringes (Figure 19).

Figure 19. A typical medication cart (Inpart Trading & Tarett, 2020).

Commonly a laptop is placed either on the countertop or on an extended surface. Drawers hold either the most common medications or medications prepared for specific patients. The medication carts were identified as a key issue and the project should try to identify a model that was better than current models to facilitate more efficient pharmaceutical work. Identifying a slimmed down model was of interest, e.g. a less cumbersome model that is easy

to transport and fit in medication rooms. Medication carts tend to be cumbersome, a bit troublesome to move around, and difficult to stow away due to their size and weight. Their size is partly a result of how they are used, which in turn is partly a result of that the carts are too big. As mentioned above in the evaluation medication carts were too big for the medication room and pharmaceutical preparation work was performed outside of the medication room instead. As a result medication carts need to be big enough to store packages of pharmaceutical to be prepared and portioned to patients. Carts also need to store medications that have been prepared for patients. This requires the carts to have numerous and sizeable drawers. However, medication carts cannot fit all medications that need to be prepared for patients. This creates a need to go between the medication room to collect medications and the medication cart to prepare or store them. Similarly, as carts have become cumbersome due to storage requirements, carts are difficult to bring when administering medications and are often left stationary. This creates a need to go between the medication cart and the patient, and back to the cart for each patient medications are administered to. If carts were more mobile they could be brought when administering medications, reducing the distance necessary to travel and reduce the time it takes to administer medications. If carts did not contain medications to prepare and portion, they could be smaller and only contain prepared medications to administer. If carts were smaller it is more likely that there would be enough space for them in the medication room. Perhaps a compromise could be made where a cart fits half, or a portion of, the prepared pharmaceutical kits to administer. It would then require only one or two trips to the medication room to reload the cart, which would still be an improvement compared to several times during preparation and several times when administering. A third workshop was held with Region Västra Götaland's publicly procured supplier of medication carts to look at slimmed down models (see Section 5.1.3).

The results of the project and workshops were presented to the project steering group. Learnings from the workshops on other pharmaceutical work, pharmaceutical preparation, and work areas were presented. The steering group gave the project group an assignment to create a prototype work area to test ergonomics and work environment. The concepts developed were explained as: i) general layout for a medication room, ii) work station for injections and infusions, iii) work station for solid medications, and iv) kit storage and less cumbersome medication carts to separate storage from transport. The project group was to formulate a standard that could be established as policy for all new and renovated medication rooms at the hospital.

Region Västra Götaland's publicly procured supplier of medication room furnishings was contacted to help construct a prototype work station. The work station was described as an adjustable height desk with shelves on the back. A number of requirements were presented, e.g. nothing was to be placed on top of the countertop everything should be mounted on a frame fixed to the back of the work station and mounts for tilted shelves should be able to be adjusted to change angle and height. The supplier's developer suggested a desk depth of

75 cm for it to handle more weight and ensure stability. Total allowed weight (including the work station) was set to 100 kg due to a width of 120 cm.

A standard document was composed by the author describing the Standard for Medication Work in Care Units (Internal document SU 2017-04096). The standard is an instruction and a framework for how medication rooms at care units at Sahlgrenska University hospital should be organised and furnished. The standard is a complement to national and regional routines and guidelines for pharmaceutical handling. In relation to these routines and guidelines the standard describes a work area where pharmaceutical preparation work operations can be performed efficiently in relation to each other. The author asked two pharmacists at the hospital pharmacy to review the document. The two pharmacists had no reservations with regards to the content and found the standard interesting. They suggested it should be presented to the Region Västra Götaland central quality organisation for medications.

5.1.1 Workshop 1: Brainstorming and creation of solution suggestions for a standardised model for work at Sahlgrenska University Hospital care units

Date: 2017-10-19. Participants: The author, the Pharmaceutical work project manager, Peter Almström, the project logistician, the registered nurse responsible for medications at the Care Ward of the Future, the project prescriptionist, one of the chief medical officers (first half of the workshop), a hospital pharmacy operations developer, the hospital pharmacy pharmacist responsible for quality review of pharmaceutical handling, a work environment strategist from Skaraborg Hospital, an associate professor in Design and Human Factors from Chalmers University of Technology, and Hanna Sundström (see 2017-04-03).

The first half of the workshop involved an introduction to the topic and relevant theory on workplace design by Peter Almström, a presentation of the present state by the author, and a presentation about ergonomics by the associate professor in Design and Human Factors. The second half of the workshop was spent working with three main topics in three groups:

1. SVD-medications, solid medications, labelling, and confidential waste handling.
2. Injections, Infusions, and unpacking medications delivered to care units.
3. Information handling, kit storage, and transporting medications to patients.

The first group discussed how to received, store, and prepare SVD-medications; placement, storage, handling, and tools for preparing solid medications; labelling and how to efficiently label medications; and where to throw away waste with patient information. The second group discussed placement, storage, handling, and tools for preparing infusions and injections; where to locate materials in relation to each other; storage prior to and in kit storage; unpacking and the placement of infusion containers. The third group discussed information handling during pharmaceutical preparation (how to best read and sign in the ordination system); the design of a kit and the kit storage and where to place a kit storage;

the design of a pharmaceutical transport (medication cart or not, if so what is a desirable design, are there any alternatives, what are the necessary functions).

The workshop provided few answers to these questions but established them as issues that needed to be clarified and resolved by the project group. The workshop served to get the involved people on the same page and acknowledge these issues as needing to be resolved. A few comments were:

- The standard should clarify that medications do not have to be administered by the same person that prepared them.
- Are measurements or blueprints of the approximately 90 different medication rooms at the hospital available?
- Will controlling stock levels and restocking be covered by the standard? (It was not)
- For injections a small working area of 20 x 20 cm is sufficient.
- To prepare a multi-membrane infusion bag a working surface of 50 x 50 cm is required. This includes the area necessary to prepare and add additives. This questioned the need for large countertops in medication rooms and the idea for work stations emerged.
- Infusion containers should be located close to where they are to be prepared and in a good working height since they tend to be heavy, e.g. delivered in boxes of 10 bags weighing a kilogram each.
- If medication carts are to be continued to be used their design needs to be developed. Patient drawers should be placed most accessibly and not too low.
- Labelling medications with (pre-)printed sticker labels instead of by hand should be possible and less time-consuming. (Possible, but currently impractical.)
- In order to find medications easier on the shelves their ATC-codes should be readily displayed in the ordination system. (Delimited from as IT-issue.)

5.1.2 Workshop 2: Work station, kit storage, and kits

Date: 2018-01-25. Participants: The author, the Pharmaceutical work project manager, Peter Almström, the project logistician, the project prescriptionist, and the two registered nurses responsible for medications at the Care Ward of the Future and Care unit Phi. The purpose of the workshop was to test preparing injections and infusions on a prototype of a work station for injections and infusions, to test preparing solid medications on a prototype of a work station for solid and quick-pick medications, and to test a prototype of a kit storage. Of particular interest was if the configuration of the work stations and kit storage in relation to the work flow was good. E.g. preparation of infusions in relation to preparation of injections and placement of infusion containers and tubing sets, placement of medications in the quick-pick shelf, placement of materials in the work stations, labelling of medications, basing the kit storage design on administration periods, and how to label kits. The project

prescriptionist and the two registered nurses acted as subjects and each prepared injections and infusions, solid medications, and SVD-medications for the respective prototype.

The workshop provided a number of learnings:

- Binders for registering withdrawals of narcotics should be placed close to where narcotics are picked and counted.
- Nothing should be fixed to the working surface to make cleaning easy.
- Adding a clock to the work station could be a good idea as all subjects turned around to look at a clock on the wall when labelling prepared medications.
- A quick reference guide for how to mix different medications and a list of how to dilute medications was requested to be at hand on the work station.
- A calculator is necessary to calculate remaining narcotics, concentration of diluted medications, and more.
- Three different types of sanitising fluids are needed on the work station: a chlorine based disinfectant to sterilize vial caps before puncturing them with syringes, an alcohol-based hand sanitiser, and a disinfectant for cleaning the work surface.
- Storage for patient specific medications is needed in addition to for administration periods in the kit storage.
- SVD-medications are not required to be checked against ordination when sorting them in the kit storage, only when administering them to patients.
- Refilling the work station with materials and medications is approximated by the subjects to be necessary once per day. Currently similar refill work is handled by the night shift once per day.

The prototype work area worked as intended and showed that the pharmaceutical preparation work could be performed in a small work area and reducing the need to move around in the room. Using a touch screen to navigate the pharmaceutical ordination list instead of a mouse and keyboard worked after some getting used to. How the kit storage should be designed and how many drawers was needed for each patient was discussed. Four drawers were suggested based on the three regular administration periods: morning, lunch, and dinner, as well as one for storing unprepared patient-specific medications such as SVD-medications. It was agreed that the author conduct a present state analysis and video record preparation of injection and infusion medications in existent medication room layouts at two care units, Phi and Upsilon, at Östra hospital. It was also decided that the author and the project logistician would measure the sizes of different pharmaceutical packages in order to determine how large the sections on the quick-pick shelf would have to be. Packages of the most commonly prepared medications at Sahlgrenska University Hospital was determined and later measured at a care unit at Östra hospital.

5.1.3 Workshop 3: Pharmaceutical work and storage in relation to medication carts

Date: 2018-03-01. Participants were the author, the Pharmaceutical work project manager, Peter Almström, the project logistician, and two representatives of Region Västra Götaland's supplier of medication carts. The representatives showed a cart of a design where different modules are mounted on a central pole with wheels. Modules were e.g. a countertop, drawers, rack for holding infusion containers, mounts for computer screens, a retractable surface for mouse and keyboard and more. It was established that a medication cart based on this design would be comparably as cumbersome as existing medication carts. One representative explained that carts often turn into 'Christmas trees' because different people need the cart to perform different functions and solve different needs for several work tasks. Regardless, it was decided to test a version of the medication cart at Care unit Phi at Östra hospital.

The author, the project logistician, and the project prescriptionist met with the prescriptionist and pharmacist at Care unit Phi. The prescriptionists and pharmacist found the medication cart to test lacking for their purposes as it was delivered without necessary details such as drawers for patient medications. Testing the kit and kit storage concept was then not possible and it was decided not to test and evaluate the medication cart. However, they provided some impressions of the medication cart. Good: Less cumbersome, Good solution mounting computer screen on an arm above the countertop. Bad: manually adjustable height function was tough with risk that the countertop rapidly jerked upwards; The countertop drawer was too small, difficult to reach, and not pulled out but the countertop rather slid off the drawer creating an uncomfortable work position; Troublesome lock function; Only room for one pharmaceutical waste container.

5.1.4 Principles For Designing The Medication Room

The foundation for how to design the medication room has been to minimise the number of steps, work method elements, and distances. By designing the medication room based on the work flow for preparing medication combined with the below principles an effective work area is made possible.

Concentration of materials based on incidence of use

Medications, materials, and tools used often shall be placed more easily accessible than those that are used less often. Thus can total required distance travelled be minimised. Inaccessible is up high, down low, or far away from a preparer's current location. If something is used often it should be at hand where there preparer is located when it is needed.

Co-location of medications and materials used together

Medications, materials, and tools used together shall be placed together. The co-location principle is an important complement to the incidence concentration principle, otherwise they are at risk at being placed to increase distance travelled.

5.1.5 Furnishings In The Medication Room

Furnishings in the medication room are: Work stations for preparing medication, Waste bins, Kit storage, Pharmaceutical storage, Infusions container storage, General storage, Refrigerator, Location for medication cart.

Work station for injections and infusions and work station for quick-pick medications

Preparation of medications differ a lot between injections and infusions and medications picked directly from a package or box (here called quick-pick). If possible, one work station of each type should be placed in the medication room. If only one can be placed, the work station for injections and infusions should be prioritised since it could be used to prepare all types of medications.

Configuration of the work stations

The work stations have the following details: (Adjustable) tilted shelves with dividers on the sides and pick-boxes in the centre of the work stations back end, a dedicated adjustable height work surface, room for placing waste bins under the work surface, touch screen on an adjustable arm, compartment under the work surface for protective paper sheets, a shelf for narcotic registration binders, wiping paper holder, work lighting, and hook for preparation of infusions. An illustration of a work station for preparing injections and infusions created and provided by Region Västra Götaland's publicly procured supplier of medication room furnishings in 2018, is shown in Figure 20.

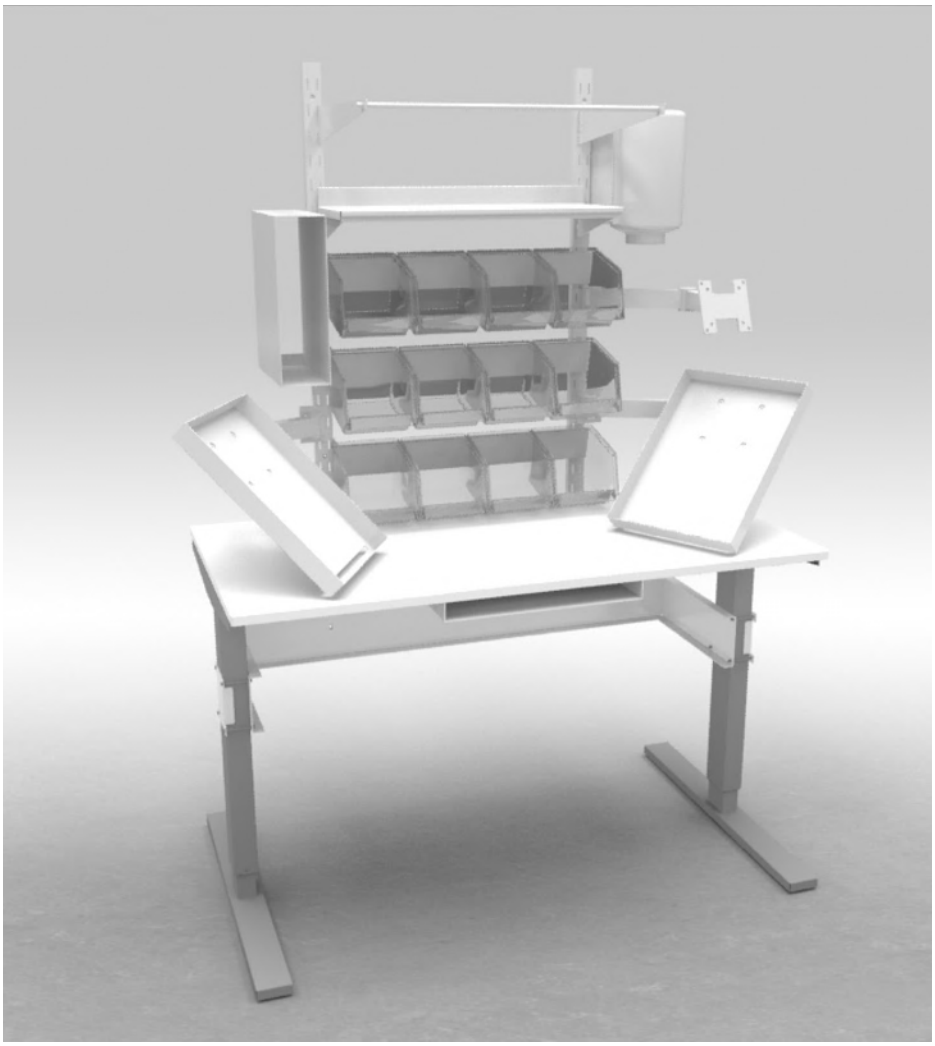

Figure 20. Work station for preparing injections and infusions (ITAB, 2018).

A work station for quick-pick medications is similar to the work station for preparing injections and infusions shown in Figure 20. The difference is that instead of the pick-boxes in the centre there are fixed tilted shelves with dividers for placing pharmaceutical packages as in a pharmaceutical storage.

Approximating a work station

A work station can be approximated following this description:

- A dedicated 60 x 60 cm work surface.
- Pharmaceutical ordination and information in direct proximity to the work surface.
    - The preparer should not have to do more than turn their body or take one step to access pharmaceutical ordination and information.
- Waste bins placed under the work surface.

- Quick-pick storage shelf of the most frequently prepared medications and used materials in direct proximity to the work surface.

Kit storage for prepared medications

A kit storage is necessary to store a patients prepared medications and enable preparation of medications separated from administering medications. Each patient should have one kit drawer for every administration period (typically morning, lunch, and dinner) and one for storing patient specific medications, e.g. unsorted SVD-medications. An example of a kit storage module with 16 kit drawers for four patients is shown in Figure 21.

Figure 21. Kit storage module for four patients (Treston, 2020).

Ideally the kit drawers should be compatible with the medication cart so that they can easily be loaded into the cart before administering.

Medication cart

The exact design of medication carts differ between suppliers but are functionally similar. Differences are commonly in the size of the cart, design of drawer module, number of drawers, size of the drawers, solution for placing laptop or tablet computer, and solution for locking the drawers in the cart. Workshop 3 (5.1.3) and the subsequent intended test did not identify a specific model but identified the key functions of a medication cart. A medication cart's primary function is to deliver medications to the patient for administering. This requires access to the pharmaceutical system for registering administered medications, separate boxes or drawers for each patient's kit of medications, waste bins of a few fractions, and perhaps a holder for infusion containers. A computer tablet or similar mounted on an arm above a countertop would be ideal as it does not take up space on the countertop like a laptop or keyboard does. If preparation work can be performed in the medication room

instead of at a medication cart, the need for storing unprepared medications in the cart is minimised and the size of the cart can be kept small and be less cumbersome as a result.

5.1.6 Placement and prioritisation of furnishings

Furnishings in the medication room should be placed based on the pharmaceutical preparation work flow. Table 12 describes at which furnishing different work operations are performed.

Table 12. Basic pharmaceutical preparation work flow, work operations, and related medication room furnishing

Order	Work operation	Furnishing
1.	Read ordination for specific patient and pharmaceutical	Work station (computer)
2.	Collect pharmaceutical	Work station, Pharmaceutical storage, Infusion container cart, or Refrigerator
3.	Collect any necessary materials and tools	Work station or General storage
4.	Prepare pharmaceutical	Work station
5.	Label pharmaceutical	Work station
6.	Throw away any waste	Work station
7.	Place prepared pharmaceutical in patient kit drawer	Kit storage
8.	Repeat the above sequence for all patients and medications	-

Much of the work flow revolves around the work stations with detours to collect medications and materials or place prepared medications in the kit storage. Prioritisation of the furnishings is determined based on how often each work operation occurs and certain practical considerations and is as follows:

1. A medication room should be furnished with a work station for injections and infusions and a work station for solid medications. If not possible the work station for injections and infusions takes precedence.
2. The work station for injections and infusions shall be placed close to a sink.
3. The kit storage shall be placed in proximity to the work stations. Closest to the work station of the type of medications most commonly prepared at the care unit.
4. Pharmaceutical storage shall be placed close to the work stations.

5. Location for the medication cart shall be placed close to the kit storage.
6. Location for the medication cart shall be placed close to the medication room entrance so that it is easily brought in and out of the room.
7. The infusion container cart or storage shall be placed close to the work station for injections and infusions.
8. The infusion container cart shall be placed close to the medication room entrance so that it is easily brought in and out of the room.
9. Refrigerator shall be placed close to the work station for injections and infusions.
10. General storage shall be placed where it fits and is needed.
11. Any waste bins that do not fit under the work stations shall be placed close to them.

5.1.7 Implementation of the Design

The Area 2 hospital facilities planner approached the author and inquired about help to plan the renovation of a small medication room at Care unit Sigma at Mölndal hospital. The author proposed for the project group that this would be an opportunity to test the Pharmaceutical work standard concepts. The Pharmaceutical work project manager emailed the hospital facility planners and inquired if any of their units were planning renovations of medication rooms, emphasising that the project should be conducted in collaboration with them. The facilities planner was coordinating the renovation together with the Region Västra Götaland's real estate management organisation's (Västfastigheter) facilities manager for Mölndal hospital. A meeting with the Area 2 hospital facilities planner and Care unit Sigma manager was set up. The work station prototype and a medication room layout sketch including a work station for injection and infusion medications and kit storage were presented. As the room was too small for accommodating two work stations the one that could handle all types of medications was prioritised.

Västfastigheter assigned a renovation project manager for the Care unit Sigma renovation which requested price for the work station. The supplier quoted price was in the region of 35,000 SEK. The author points out that the total budget for renovation was 100,000 SEK and the work station would consume 35% of it. The renovation project manager replied that the work station could be paid by the care unit instead and thus not be counted toward the renovation budget. The author asked if the regional procurement organisation could be involved instead to negotiate the price before placing an order. The renovation project manager stated that a 100,000 SEK budget is far too low with regard to the renovation costs and that the project would cost about 200,000-210,000 SEK. The author then contacted the hospital's procurement strategist for help who said that Västfastigheter seldom negotiate price even though they should. The author contacted the supplier sales person and explained that the work station is too expensive which created problems regarding the budget for the renovation. The author emphasised it was in their interest to account for part of the development cost and asked for a cost breakdown. The price was lowered to around 25,000 SEK but no cost breakdown was provided. Later, the renovation of the medication room at Care unit Sigma was approved by the area 2 area manager, the budget was doubled, and the

work station was ordered by the renovation project manager. The hospital facilities planner did not initiate any discussion regarding if there was anything in the renovation that needed to be adjusted as the offer exceeded the budget. On 2018-11-22 the renovation contractor notified the care unit that renovation would start on 2018-11-26. The author was not notified and was under the impression that the renovation would start after the Christmas holidays. Therefore a current state analysis would have to be conducted at a medication room at Care unit Xi that was configured identically. On 2018-12-18 the renovation project manager announced that the final inspection of the medication room at Care unit Sigma was to be conducted on 2018-12-20. The author could not attend and rushed to inspect the day prior. The care unit manager cancelled a day's planned leave to attend. A wider set of shelves for pharmaceutical storage than specified had been installed resulting in the kit storage not having been installed due to lack of space. This was later solved by moving light switches and power outlets by the doorway to the other side of the doorway to fit the kit storage in the specified location between the pharmaceutical storage and the doorway.

Another possible medication room renovation was identified at an Infection care unit but it was similar to the one being renovated at Care unit Sigma and the Medication Work project group decided that a different configuration of medication room would be better for testing. A hospital project manager for the renovation of care units Rho, pi, and Omicron at the Sahlgrenska hospital main building later asked if the Pharmaceutical work project manager could help oversee the design of the medication rooms. The author and the Pharmaceutical work project manager met with the Area 6 facilities planner and the architect to discuss potential design of the medication rooms. The hospital renovation project manager and Area 3 facilities planner do not attend. A meeting about the medication rooms was set up with the Pharmaceutical work project manager, the hospital renovation project manager, facility planners for Areas 3 and 6, and care unit managers for care units Rho, Pi, and Omicron. There was confusion regarding which rooms would be medication rooms and if each care unit should have one or two medication rooms. In order for the renovation project to progress the hospital renovation project manager decided to specify generic configurations for the medication rooms until the confusion was sorted out. Another meeting was held with the hospital facilities planners and the care unit managers. The author presented the standard as a toolbox for furnishing a medication room and emphasised that it was not a rigid concept that was supposed to look identical regardless of room. Instead it is to furnishing a room to result in the best possible work area for a particular room. The standard document was emailed to the care unit managers for consideration and the would notify the author of their decisions after a week. None of care units Rho, Pi, or Omicron wanted to furnish their medication rooms based on the standard. The care unit manager for Rho said they were not interested in furnishing the medication room based on the standard and the care unit manager for Omicron said they would rather plan their medication rooms themselves. The Medication Work project steering group decided that the Pharmaceutical work standard would be presented to the Function group for Quality and Patient safety and ask the attending area development managers to ask their facilities planners why the care units had

turned down to use the standard. No further reasons were communicated to the project group.

A former colleague to the author wondered if the author could help to design a medication room in conjunction with the move of Care unit Nu. The former colleague spoke with the care unit manager who wanted to get it done but had trouble following through. The author emailed the care unit manager to ask if they would like help to review the medication room but received no reply. The Area 2 facilities planner inquired if the author could help design a medication room at Care unit Mu at Högsbo hospital. The author met with the care unit manager and prescriptionist and discovered a blueprint taped to a window which showed planned furnishings in the medication room. The care unit manager investigated and later notified the author that furnishings had already been ordered and that they would proceed with the plan from the blueprint. The author had also heard about Care unit Lambda to be renovated and open at Mölndal hospital. The care unit manager was positive to applying the standard and contacted the Area 3 facilities planner who replied it was too late to change the design of the room. This facilities planner had been involved in the planning for care units Rho, Pi, and Omicron and previously been informed on several previous occasions that the Pharmaceutical work project was looking for medication rooms that were to be designed according to the developed standard.

5.2 Systematic Work Activity Mapping Project Results

Prior to this project there had been activity mappings conducted at Sahlgrenska University Hospital throughout the years in different projects, using different methods, and with varying purposes. The results of these mappings had not been reused to any greater extent but rather remained localised to the units (e.g. care unit, emergency care unit etc.) involved in the different projects. There are, and have been, several motives for conducting activity mapping, including:

- To be able to describe in a shared patient care plan what is planned to be done. This is central to person-centred care (Ekman et al., 2015).
- To know that an activity has been performed and describe how it is performed. This is central to patient safety (SOSFS 2011:9, Ch. 4 § 3).
- To describe who does what and when. This is important for workload and psychosocial work environment (AFS 2015:4, §§ 9-10). To describe who does what is also a prerequisite for distribution of work and job (role) descriptions.

According to the Swedish Work Environment Authority regulation (ibid. § 10) an employer should make sure that employees know:

1. which work tasks they should perform,
2. which results to be achieved by the work,

3. if there are any particular ways in which the work is to be performed and if then how to perform it,
4. which work tasks to be prioritised when the available time is not enough for performing all work tasks that should be performed, and
5. who they can turn to for help and support to perform the work.

To be able to provide this information work activities (work tasks) need to be identified and denominated. Activity mapping is a way of doing this. The idea behind the Systematic Work Activity Mapping project (the Mapping Project) was to provide a systematic method and a structure where the same denomination is used for the same work activity despite being performed at different units. Thus the purposes of the Mapping Project included to:

1. Develop a method and a structure for systematic work activity mapping.
2. Investigate different alternatives for IT support for the structure. (Data should be stored in a database.)
3. Test the method and structure at about ten units representing different specialities at the hospital.

Additionally there were a number of requirements for the structure and the method to fulfil.

- The structure shall be systematic and support prior motives for conducting activity mapping.
- The structure shall be implemented in a database.
- The same method shall be able to be used at different types of units and medical specialties.
- The method shall be efficient to use and it should not take more than 1-2 hours per unit for the unit manager and a few personnel to map all work activities at the unit together with a method expert facilitating.
- Work activities shall be formulated so that they can be used across units and medical specialties (where applicable).
    - Consideration shall be made between this generalisability and the need of exact description of activities.

A project group was put together consisting of a project manager from the Analysis and project unit, the author as researcher and development manager, Peter Almström as strategic advisor, a data analyst from the analysis and project unit, and two senior HR specialists specialised in scheduling and work activities. A steering group was appointed for the project, consisting of one of the assistant hospital executive directors, one of the chief medical officers, and the Analysis and project unit manager. The project ran from November 2017 throughout June 2018. At the first project meeting the following points were discussed:

- At which level of detail should work activities be described?
- Should work activities be organised in 'packages'? E.g. 'surgical care unit' consisting of base package 'care unit' with addition 'surgical'. (No,
- What data needs to be collected?
    - Activity description? (Yes),
    - Work method? (No, not within scope),
    - Required competence (Partly, only care unit personnel in scope),
    - Time consumption? (No, not within scope),
    - Frequency of activities? (No, not within scope).
- Which types of units should the project start with?
    - Not Support units such as the Finance department or HR department.
- How should data be collected?
    - Group interview or focus group at care units with care unit personnel.
- Who should collect data? Members of the project group in different constellations, not single members. Base the interviews around a list of activities.

In order to decide on a suitable delimitation of care units to investigate all care units at Sahlgrenska University Hospital were identified and categorised based on medical specialty. A list of categorised units was created. Units were categorised as Paediatrics, Medicine, Surgery, Psychiatry, or Combined care (e.g. emergency care). It was decided that the project should focus on the care units that would provide the most (useful) information for the hospital. That meant to focus on inpatient care (being uniquely hospital care) and to focus on the Medicine and Surgery specialties since they constitute the two largest blocks of care units. The project group decided to try to investigate five Medicine care units and five Surgery care units from the different hospital Areas and hospital locations in Gothenburg (see Section 3.3). The easiest way to reach out to care units was decided to be through existing contacts of the project group members. It was decided that the work activity investigation should focus on the work activities performed by the personnel employed at the care units. I.e. to not include work activities carried out at a care unit by personnel employed elsewhere, e.g. by consulting physicians or physiotherapists. Investigation of work activities carried out by such personnel would occur when investigating such units, e.g. a physician unit or physiotherapy unit.

A work activity list draft was created. The term 'work activity list' refers to a list of work activities structured according to the activity structure. It was decided that the work activity list would be updated in the project group meeting following a care unit visit. The basis of the draft was a list of activities from a previous HR project for scheduling personnel based on the required competence to perform different activities. Work activities were denominated in both verb form and noun form, e.g. 'Dispense medications' (verb form) or 'Food and drink distribution to patient' (noun form). The first draft list was structured hierarchically according to 1. Type of work, 2. Work activity category, and 3. Work activity.

Types of work were: Direct patient work, Indirect patient work, Service work, and Miscellaneous. The structure of the work activity list draft was soon deemed to be non-intuitive. If a work activity was Direct or Indirect patient work was not something that was important or considered by the personnel that carried out the work activities. A new work activity list was created, Version 1. Activities remained organised in a hierarchical structure but the previous top level 'Type of work' was removed, the new highest level became 'Work activity categories', and the next level became 'Work activities', i.e. a Level 1 Work activity category includes a number of Level 2 Work activities. Section 5.2.2 goes into more detail on the Systematic Work Activity Structure. It was also decided that the denomination of work activities should be in verb form to distinguish them as acts and to be denominated as close to care unit personnel's' everyday language as possible without compromising specificity. Section 5.2.3 goes into more detail on work activity denomination. Additionally, the data analyst, the strategic advisor, and the author as development manager were tasked to prepare specification material for a Work Activity Structure Database (see Section 5.2.4). The specification was intended to outline which functionality was required, not identify specific database software. Functionality in turn guides the requirements for how a database is to be constructed.

A total of nine care units were visited and investigated during the project. Table 13 presents the care units in the order they were visited and their medical specialties. The identities of the specific care units have been anonymised.

Table 13. Investigated care units and their medical specialties

Care unit	Medical specialty
Alpha	Surgery (emergency)
Beta	Medicine, Geriatrics, and Cardiology
Gamma	Infection
Delta	Medicine (emergency)
Epsilon	Surgery
Zeta	Surgery
Eta	Gynaecology, Oncology
Theta	Medicine and Geriatrics (emergency)
Iota	Transplantation

Version 2 of the activity list was created after visiting care units Alpha, Beta, and Gamma. All activities and comments brought up by the care units were discussed by the project group.

A key takeaway for subsequent care unit visits was that it was important for the care units to focus on and present work activities that were specific to them. Version 3 of the work activity list was created after visiting care unit Delta. Version 4 was created after visiting care units Epsilon, Zeta, Eta, and Theta. Version 5 was created after visiting care unit Iota. The number of activities commented on at care unit visits and the number of new activities, rephrased activities, and removed activities during work activity list updates are presented in Table 14.

Table 14. Care unit visits and work activity list updates

Care unit Alpha visit	15 activities commented
Care unit Beta visit	28 activities commented
Care unit Gamma visit	23 activities commented
Updated the work activity list	17 new activities, 1 rephrased
Care unit Delta visit	20 activities commented
Updated the work activity list	2 new activities, 5 rephrased, 1 removed (included in another activity)
Care unit Epsilon visit	14 activities commented
Care unit Zeta visit	9 activities commented
Care unit Eta visit	38 activities commented
Care unit Theta visit	14 activities commented
Updated the work activity list	10 new activities, 5 rephrased
Care unit Iota visit	28 activities commented
Updated the work activity list	4 new activities, 1 rephrased, 1 removed (included in another activity)

A brief comparison between Version 1 and Version 5 of the work activity list is presented in Table 15. The fifth and final version of the work activity list is presented in Appendix I.

Table 15. Comparison between the first and final work activity lists

First activity list version	Final activity list version
19 Level 1 Work activity categories	19 Level 1 Work activity categories
102 Level 2 Work activities	132 Level 2 Work activities

There were a total of 188 commented work activities and work activity categories by the investigated care units. No new Level 1 Work activity categories were created. However, there were 32 new Level 2 Work activities of which 2 were included in other work activities, resulting in a net of 30 new Level 2 Work activities. 18 denominations were changed. Comments that did not lead to the addition of a new work activity to the list or a denomination change were kept as commentary to the pertaining Level 2 Work activity if they exemplified related prospective Level 3 Work activity variants.

5.2.1 Systematic Work Activity Mapping Method

In this see Section the method for conducting Systematic Work Activity Mapping is summarised.

Step 1: Create an initial list of work activities

Create an initial list of activities, either based on previous mappings of work activities or by brainstorming activities. A lot of work activities from care wards are the same as those performed at e.g. emergency care units or operating units. Some of the activities such as 'Take a break' or 'Train a colleague' are performed at all types of units.

Step 2: Develop and validate the list with support from personnel from the units

Personnel from different professions and the unit manager go through the list to comment on work activities on the list and to bring up work activities that are performed at the unit but are not on the list. A Systematic Work Activity Mapping expert assists them with explaining the work activity structure and elaborate on what work is entailed in the denomination of specific work activities on the list. Work activities on the list are marked as 'performed' or 'not performed' for each unit.

The process of a unit visit

A unit visit is a meeting between 2-3 personnel from a unit, e.g. a care unit, and two 'method experts' (in this instance project group members). The unit personnel should preferably be of different professions, e.g. registered nurse and assistant nurse in the case of a care unit, and preferably include the unit manager. This is to provide an as all-encompassing view of work activities performed at a unit. The roles of the method experts are for one to facilitate the discussion while the other documents comments on work activities and new work activities on the list. The work activity list serves as the focus of discussion. It is necessary to either have printed paper versions of the list, display it via projector, or provide some other way in which the work activity list is easily viewable by the unit personnel. The list can also be provided prior to the unit visit (though it had rarely been previewed in the conducted care unit visits). The meeting duration is around one hour, which is how long it typically took to go through and discuss the items on the list and any work activities missing from it.

The aim of the facilitating expert is to get the unit personnel to provide detail or additional or related information to work activities on the work activity list. This is in order to provide

the basis for adding new work activities to the list, refine work activity denominations, or distinguish between work activities that warrants the creation of new work activities. The work activity list is gone through work activity by work activity, work activity category by work activity category. At the end of each category see Section the unit personnel are asked if there are any other work activities of that type that they perform that are not on the work activity list.

Having a conversational tone when inquiring about work activities is valuable because it invites discussion. Asking the unit personnel to describe a typical day's work, the patient pathway, or a particular work activity or process (such as service or treatments they provide) provides a context for the facilitator to latch on to and ask follow-up questions. Questions in the vein of 'Could you describe [X]…?', 'What about [Y]…?', or 'What happens before/after [Z]?' is a good complement to going through the work activity list from top to bottom. Starting to go through the list is a good way to start the meeting to then ask more inquiring and open-ended questions. Not asking these types of questions could stifle discussion and limit inquiry to work activities already on the list.

Step 3: Process comments, add work activities, and refine denominations

Comments to change work activity denominations and add new work activities to the work activity list (and the work activity structure) are handled as individual suggestions. A method expert or decision group (in this instance the project group) decide to either incorporate the change/addition, incorporate it with modification (e.g. by modifying a suggested denomination), merge it with another suggestion or existing denomination, or to reject the suggestion if the work activity already exists or should be categorised at another level such as a Level 3 Work activity variant of a Level 2 Work activity if applicable (in this instance the project was limited to Level 1 Work categories and Level 2 Work activities, Work activity variants were handled as comments to Work activities).

Step 4: Net work activity list complete

After any changes and additions a complete list of work activities of the investigated units is completed. Each unit also have unit specific lists of work activities performed at the specific units.

5.2.2 Systematic Work Activity Structure

The structure used in the Mapping project was limited to two levels, Level 1 Work activity categories and Level 2 Work activities. These are the top two levels in a hierarchical work activity structure consisting of six levels (Figure 22).

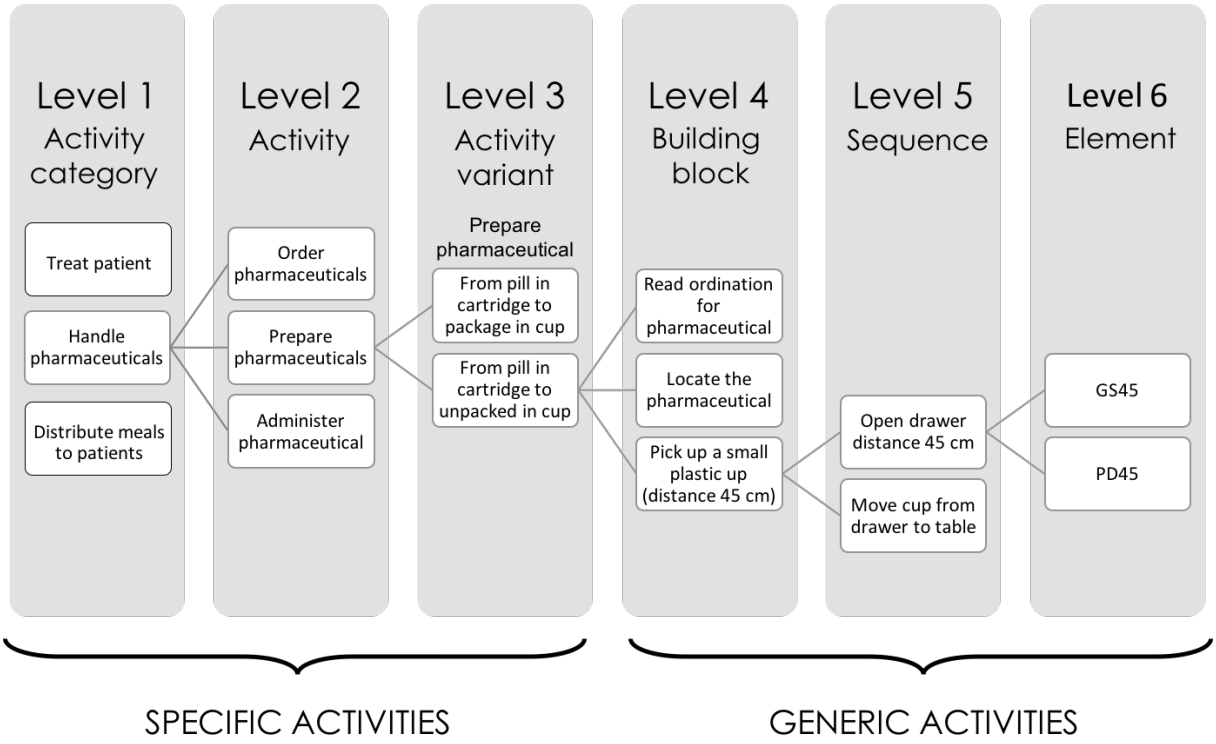

Figure 22. Systematic Work Activity Structure (updated from Hermansson & Almström, 2018).

At Levels 1-3 each entry in the work activity structure is described in more detail, i.e. Level 1 is Work activity category, Level 2 is Work activity, and Level 3 is Work activity variant. It is worth noting that not all Level 2 Work activities have subordinate Level 3 Work activity variants. Level 1-3 items are specific items, meaning each item is discrete from other items, e.g. Level 1 Treat patient and Level 1 Examine patient. Levels 4-6 are general items common for many Level 1-3 entries, where entries are 'generic' building blocks on each level. Level 6, Work activity element, is the 'atom level', where each movement has a standard denomination consistent with MTM-SAM (see Section 2.3.1). Level 5 is Work activity sequence, where elements are combined into sequences. Level 4 is Work activity operation where sequences are combined into general description of how to perform a Level 2 Work activity or Level 3 Work activity variant. Levels 5 and 6 thus provide more detailed descriptions for how to perform work.

5.2.3 Work Activity Denomination

This section outlines how work activities were denominated as decided by the project group, initially in the project group meeting on 2018-01-16. All work activities have been denominated according to the following rules:

1. A work activity denomination must begin with a base form verb.
    a. For the denomination to indicate action, that something is performed.

2. A work activity denomination should be as described by many and which most people/personnel immediately can associate with the right work activity.
    a. In order for a denomination to be characterised by recognisability and specificity.
3. A work activity category, work activity, or work activity variant should be unique, discrete, and not be part of any other work activity category, work activity, or work activity variant.
    a. In order to not confuse activities or their way of being performed.

5.2.4 Specification of Requirements for Work Activity Mapping Data Structure and Data Management

The specification of data structure and data handling for a Work Activity Structure Database was established as follows:

Database structure

- Data shall be saved in a database that can be connected to different interfaces so that data can be used for different purposes.

Purpose of use

- Future healthcare planning system.
- Future healthcare process managing system.
- Future work instructions.
- Connecting work activities directly to relevant laws, guidelines, and routines.
- Distribution of work and personnel scheduling at unit level.

Data entry

- Flexible interface, preferably a web interface, should be possible to use on both personal computers (independent of operating system) and handheld devices.
- Data shall be flagged as e.g. desired change that then needs to be approved by a super-user.
- Changes should be traceable with version management of activities and logs of changes.

Data extraction

- It shall be possible to generate an excel file of work activities for every unit.
- Connections to future planning and processing systems.

Administration of structure and content

- It shall be possible to add levels in the structure.
- It shall be possible to add attributes to objects. (Objects are activities at any level.)

- Attributes (initial): Activity denomination, Level, Identification number, Description, Connection to 'super-activity' ('super-' meaning 'above'), Classification [All, Somatic, Psychiatry, Surgery, Medicine, Clinic, Care unit]

Users and their responsibility

- Expert users / super-users: Administer the database.
- Operations developers / expert users: Understand the work activity definitions.
- Unit managers: Ensure information for their unit is correct and useful.

6 ANALYSIS

This chapter constitutes the analysis of the Standard for Medication Work in Care Units project and the Systematic Work Activity Mapping project. Both project sections begin with a summary of the corresponding appended paper which is followed by a section on design science research aspects: Field problem and Design problem, Object-design, Realisation-design, and Process-design.

6.1 Standard for Medication Work in Care Units Project Analysis

This section first presents a summary of Paper 1 followed by a design science research aspects analysis. The section corresponds to Research Question 1: How should pharmaceutical work at a hospital care unit be improved to become more efficient?

6.1.1 Summary of Appended Paper I

The following section is a brief summary of the appended paper concerning the Standard for Medication Work in Care Units project: 'Productivity potentials at hospital wards – The case of pharmaceuticals dispensing' (Hermansson & Almström, 2016).

Increased productivity in order to meet future demands for healthcare can be achieved by using work studies to improve work methods and reduce non-value-adding time on a detailed level. Appended paper 1 demonstrates the potential productivity increase by improving resource efficiency for the pharmaceutical preparation work activity. A work sampling study previously conducted at Sahlgrenska University Hospital is presented and a video recorded sequence of pharmaceutical preparation was analysed using MTM-SAM. The work method was then standardised and the work area redesigned. The redesign involved eliminating unnecessary work elements and re-organising the medication room to facilitate these eliminations in order to reduce time spent walking, searching, and collecting. Modelling the redesign and using the same video recorded sequence to compare the current state and redesigned state the time for conducting the sequence is reduced from 29 min 36 s to 7 min 39 s. Thus, a potential 287.1% potential productivity increase is shown.

6.1.2 Field problem and Design problem

The results of the Master's student project established the field problem: the problem situation that can be improved (see Section 4.1.2). The medication room did not support the personnel in their work and significant time was spent searching for materials and collecting them. The introduction of SVD-medications in addition to existing pharmaceutical types was an opportunity to review the configuration of medication rooms to suit pharmaceutical work. The design problem, the problem of improving the field problem, was delimited to work performed in the medication room and the related furnishings and work area: storage, preparation, labelling, waste handling, and transportation of prepared medications for

administration. The pharmaceutical work was identified by following along preparers as receiving delivered medications, packing up, preparing medication, any temporary storage of prepared medications, preparing transport of medications to patients, and ordering medications. Medication cart design was also identified as an issue as they sometimes did not fit in medication rooms and resulted in pharmaceutical preparation being performed outside of medication rooms. Interruptions to pharmaceutical work were frequent as a result. Addressing and altering the design of medication carts later proved to not be possible within the scope of the project and making recommendations for altering existing carts had to be settled for. The project focused on reducing the time required to prepare medications in the medication room.

6.1.3 Object-design

The project object-design, the design of the intervention, is multi-facetted. It is best described in the excerpts from the standard document which outlines the principles for designing the medication room, furnishings in the medication room, and placement and prioritisation of furnishings (Sections 5.1.4 to 5.1.6). The two principles are Concentration of materials based on incidence of use and Co-location of medications and materials used together. The furnishings emphasised are the work stations and the kit storage and their configuration. The placement and prioritisation of furnishings describes in which order to place furnishings and how to place them in relation to other furnishings.

The relocation of medications and materials in the medication room (see Section 4.1.3) provided early input to the two principles and the pharmaceutical preparation work flow which guided the development of the object-design. A precision weighing scale for counting narcotics was proposed to be introduced but the ideas was later discarded on account of not entailing a significant improvement. The first workshop about pharmaceutical work at care units yielded a number of input to the object-design, e.g. that infusion containers should be placed close to where they are prepared, that the work surface area required to prepare infusions and injections was 50 x 50 cm and 20 x 20 cm respectively questioning the need for large countertops, as well as pharmaceutical labelling with sticker labels. The sticker label idea was dropped from the standard as no straightforward way of printing the information was available.

Based on a mapping of medication rooms in Region Västra Götaland by H. Sundström (2017) an ideal layout of a generic medication room was created based on input from the relocation of pharmaceutical and materials pre-study (4.1.3) and input from Workshop 1 (2017-10-19). A number of ideas emerged in the creation of the ideal layout. The idea of a kit storage for storing prepared medications to separate preparation work from administration work. The idea of work stations for preparing medication and that two types of work stations were identified, one for injections and infusions and one for solid medications. The idea of a quick-pick shelf on the work station for solid medications for

preparing the most frequently prepared medications in order to reduce the need for the preparer to go and collect medications.

Prototypes of the ideas were created and tested at Workshop 2 (2018-01-25) where the ideas held up and only details of the work stations and kit storage were adjusted. Nothing was to be mounted on the work surface and instead be mounted on a frame fixed to the back of the work station to which shelves and other details should be mounted. The basic requirement of four kit drawers per patient in the kit storage was established, one for each administration period and one for storing patient-specific medications. Modules of four sets of four drawers was established as a scalable solution for kit storage. The size of compartments on the quick-pick shelf was determined to fit the size of common pharmaceutical packages. The furnishings supplier adjusted the work station depth to from 60 to 75 cm and the width to 120 cm to ensure stability and weight requirements. A standard document describing the object-design was created and ratified by pharmacists at the hospital pharmacy (2019-09-11):

- Purpose for the standard
    - Free up time from pharmaceutical work for the benefit of other work
    - Improve ergonomics in pharmaceutical work
    - Prepare for implementation of SVD-medications at care units
- Principles for furnishing medication rooms (see Section 5.1.5)
    - Concentration of materials based on incidence of use
    - Co-location of materials used together
    - Enabling preparation separated from administering medications
    - Simple ergonomic rules
- Furnishings
    - Work station for preparation of medications (see Section 5.1.5)
        - One version for injections and infusions and one for solid medications.
        - Configuration and specification of the work stations
        - Approximating the work stations
    - Waste handling
    - Kit storage (see Section 5.1.5)
        - Configuration of kit storage
        - Compatibility with medication cart
        - Labelling of medications in kit storage
    - Storing medications
        - Comment on safety lockers for storing narcotics
        - Quick-pick shelf for storing the most commonly prepared medications
    - Infusion container cart and storing infusion containers
    - General storage

    - Refrigerator
    - Medication cart location in the medication room
        - Configuration of medication carts
    - Comment on biosafety cabinets for preparing medication
- The placement and prioritisation of furnishings (see Section 5.1.6)
- Work method for SVD-medications at care units
    - The SVD-pharmaceutical delivery process
    - Unpacking
    - Preparation
    - Before administering
        - Transportation
        - Waste handling
- Identifying medications for quick-pick shelf storage

6.1.4 Realisation-design

A realisation-design is the plan for the implementation of the intervention. For the Standard for Medication Work in Care Units project a pre-study making changes to a medication room was conducted prior, which provided a pharmaceutical preparation work flow and inspired principles for furnishing medication rooms (2016-12-12). To start off the project top management approval was necessary, in this case from the hospital executive director, and to meet with the hospital pharmacy manager and hospital pharmaceutical operations manager to establish the initiative and hospital pharmacy cooperation (2017-01-25). Alignment with any related projects needs to be at least attempted, in this case the SVD-pharmaceutical implementation project (2017-03-13). For the Pharmaceutical work project the author and the project logistician attended SVD-pharmaceutical project meetings to identify touchpoints where the two projects would intersect (2018-01-18). The Pharmaceutical work project was extended after establishing a work method for handling SVD-medications at care units to also create a prototype work area to test ergonomics and work environment (2018-03-23, 2018-05-29).

In order to create and test a prototype work area the physical space variation that needs to be adapted to needs to be investigated. In this case, a Master's student project mapped medication rooms at hospitals in Region Västra Götaland (2017-04-03; 2017-12-20; H. Sundström, 2017). A project group also needs to be established. The project group needs to include individuals with knowledge related to pharmaceutical handling and preparation and work place design. In this case the former were represented by a registered nurse and a prescriptionist and the latter by the author and Peter Almström, associate professor in Production analysis (2017-05-09). A project manager and a hospital logistician completed the project group.

It is necessary to seek help from outside the project group. Hospital pharmacists provided assistance on regulations, routines, and established practice (2017-05-23). The hospital

pharmacy operations developer shared an evaluation of prescriptionists at a care unit and issues with pharmaceutical work there, which revealed medication carts as an issue and the project took on trying to identify cart models that better facilitated pharmaceutical (preparation) work (2017-11-17). Identifying a slimmed down, less cumbersome model that is easy to transport and fits in medication rooms was of interest (2018-01-05). A workshop was held to review such models with the hospital's medication cart supplier and a cart was selected for testing at a care unit (2018-03-01). When reviewed by the prescriptionists intended to conduct the test they found it delivered insufficiently equipped for testing (2018-06-05). Two pharmacists were asked to ratify and give feedback on the Pharmaceutical work project standard document and did not have any reservations regarding the content and asked if it would be possible to have it presented for the Region Västra Götaland central quality organisation for medications (2019-09-11).

Rules and regulations need to be identified and adhered to such as pharmaceutical labelling requirements; controlling pharmaceutical information; quality and safety requirements when preparing injections, infusions, antibiotics, perishable medications, and other medications (2017-06-16, 2018-01-02). Rules, regulations, and routines are established at different levels. At the national level by e.g. the Swedish Association of Local Authorities and Regions, the Swedish National Board of Health and Welfare, and the Swedish Medical Products Agency. At the regional level, at the hospital level, at the department, and at the unit level. Routines are commonly created locally at the department or care unit level because an overarching routine is not specific enough to regulate the circumstances at the lower level. Certain overarching routines can also be deviated from to some degree by creating a local routine where a unit or department manager takes responsibility for consequences arising from deviating from the overarching routine to adapt to the local context. The Care Handbook (*Vårdhandboken*) is a collection of national guidelines for performing many direct-patient activities. Region Västra Götaland's guidelines for handling and preparing medication specifies certain work elements focusing on quality, safety, and medical integrity. Information on frequency of administered medications also needs to be obtained. In this case the author had to rely on pharmacists and prescriptionists to obtain data on ordered medications as a proxy for administered medications as data on actual pharmaceutical consumption was not possible to obtain on an aggregated level (2017-09-15, 2017-10-04). The data was used to determine which medications were to be placed more easily accessible (2018-12-18).

An ideal generic layout needs to be created. A number of ideas emerged in the creation of the ideal layout based on input from the relocation of pharmaceutical and materials pre-study (4.1.3) and input from Workshop 1 (2017-10-19, 2017-12-20). The idea of a kit storage for storing prepared medications to separate preparation work from administration work. The idea of work stations for preparing medication and that two types of work stations were identified, one for injections and infusions and one for solid medications. The idea of a quick-pick shelf on the work station for solid medications for preparing the most frequently prepared medications in order to reduce the need for the preparer to go and collect

medications. These ideas need to be prototyped and tested, initially in a workshop setting (2017-12-20, 2018-01-25). Workshop 2 (2018-01-25) the configuration of the kit storage and work stations prototypes was tested in relation to the pharmaceutical preparation work flow for injections, infusions, solid medications, and SVD-medications by two registered nurses and a prescriptionist.

The configuration of the work stations and kit storage (as new furnishings in a medication room context) need to be established. The basic kit storage requirements were established to be four kit drawers per patient based on the three regular administration periods and a drawer for patient-specific medications (2018-02-01). The hospital's supplier of medication room furnishings was engaged in developing the work stations (2018-04-05, 2018-05-09). The supplier adjusted the configuration in order for the work station to be able to fulfil requirements, such as depth to ensure stability and load requirements (2018-05-16).

It is also necessary to spread the word about the project. The project was presented for the SVD-pharmaceutical project group consisting of individuals from different parts of the hospital organisation: the Care Pharmacology Unit manager, the Area 2 Development manager, a member of the hospital Strategic Quality Council, the hospital pharmacy operations developer, a unit manager of a Medicine and Geriatrics care unit, a physician in Geriatrics, and two nurses from a Urology care unit (2018-02-08). Spreading the word led to the Area 2 hospital facilities planner approaching the author to inquire about help to renovate a small medication room at Care unit Sigma, which became a test location for the object-design (2018-05-30). The Pharmaceutical work project and the work station prototype was then introduced to the Area 2 hospital facilities planner and the Care unit Sigma manager (2018-06-28). This contact revealed the hospital facilities planners to be key stakeholders and they were then all contacted to inquire about any other medication rooms to be renovated (2018-08-05). The Pharmaceutical work project manager was notified about another prospective medication room, but it was too similar to the Care unit Sigma room to warrant inclusion (2018-10-09). A hospital project manager later asks for help in the renovation of three care unit medication rooms at care units Rho, Pi, and Omicron (2018-11-21). A former colleague to the author asked for help with designing a medication room for a move of Care unit Nu, but nothing came of it (2019-02-01). The Area 2 hospital facilities manager asked for help to design a medication room for a move of Care unit Mu (2019-02-12). These care units were all prospective test locations for the object-design. Care unit Lambda was also identified as a prospective a prospective test location, but when contacted the Area 3 facilities planner replied that it was too late despite being previously informed of the project's interest in medication rooms (2019-11-15, 2019-11-27). The author was also asked to take part in a public procurement process for medication room furnishings by a member of the Region Västra Götaland Facility Management Procurement Steering Group (2019-06-05).

The object-design of course needed to be implemented. A blueprint of the re-designed medication room was presented to the Area 2 facilities planner and the Care unit Sigma manager for review (2018-09-09). For a renovation which responsibilities are in the domain

of the hospital organisation and which are in the domain of the property management organisation needs to be clarified. The Region Västra Götaland's property management organisation Västfastigheter was contacted about their project routines and who was supposed to pay for what of the renovation (2018-09-12). Västfastigheter appointed a project manager to plan the renovation project and calculate the costs including the work station (2018-09-19, 2018-09-20). The care unit and the author considered the price for the work station to be high and a too large share of the renovation budget and asked if the renovation project manager could negotiate the price (2018-09-26). The response was that the budget was too low and the price for the work station was in the end negotiated by the author (2018-09-28). The renovation project and doubled budget was later approved by the Area 2 area manager without the hospital facilities planner inviting to discuss any adjustments to the project to better fit the budget (2018-10-10). The renovation contractor notified the care unit with short notice that the renovation would start 2018-11-26 but neither informed anyone in the Pharmaceutical work project group (2018-11-22). As a result there were difficulties to conduct a current state analysis (2018-12-03, 2018-12-06). The work station was installed on 2018-12-13. The final inspection of the renovated medication room was also announced with short notice for 2018-12-20 (2018-12-18).

A meeting was held about the design of the medication room at Care unit Mu with the care unit manager and care unit prescriptionist, but as it was revealed that the room had already been designed the care unit manager decided not to proceed with designing the room according to the Pharmaceutical work project standard (2019-03-07).

The potential re-design of the medication rooms at care units Rho, Pi, and Omicron was also discussed (2018-11-29). A meeting was held with the hospital renovation project manager, Area 3 and 6 hospital facilities planners, and care unit Rho, Pi, and Omicron unit managers who could not reach a decision on how to furnish their medication rooms (2019-02-18). A further meeting was held with the facilities planners to explain the standard (2019-10-15). Another meeting with the facilities planners and the care unit managers was held where it was emphasised that the standard was a toolbox and that the aim was to help them design the best possible work area for pharmaceutical preparation (2019-10-24). All the care unit managers declined to use the standard (2019-10-31). This led to inquiries as to why they declined, further informing all the hospital facilities planners, and appeal to the Function group for Quality and Patient safety to help, which included the superiors of the facilities planners (2019-11-11, 2019-12-12, 2020-01-09).

6.1.5 Process-design

This section describes how the process-design (the plan for the Problem Solving Cycle and the method used to design the solution to the problem) developed throughout the Standard for Medication Work in Care Units project. To recap the Problem Solving Cycle see page 29.

How the problem is defined and the problem situation was diagnosed is outlined in the Field problem and Design problem section above. With regards to the plan of intervention, the

diagnosis of the problem situation is described in the Object-design and Realisation-design sections above. Workshop 1 entailed exploration of the problem situation and diagnosis of it, which led to several questions being raised and issues to be solved in the project (2017-10-19). The Object-design section also includes descriptions of how the solution design evolved.

How the intervention was applied is described in the Realisation-design section above. The intervention was applied at Care unit Sigma as described in the Realisation-design section and excerpts 2018-05-30, 2018-06-28, and 2019-02-12 and attempted to be applied on several more occasions, excerpts: 2018-08-15, 2018-10-09, 2018-11-21, 2019-02-01, 2019-02-18, 2019-03-07, 2019-10-24, 2019-10-31, 2019-11-15, 2019-11-27, and 2019-12-12. It is clear that it is up to the care unit managers how they want to furnish the medication rooms and that the hospital facilities planners are key to identify and inform care units of the standard for how to design medication rooms.

The intervention and object-design was mainly evaluated continuously during the progression of the project, such evaluation is described in the Object-design and Realisation-design sections above. It was decided not to conduct an extensive test and evaluation of a new medication cart (2018-06-05). Pharmaceutical preparation work was video recorded for current state analyses at care units Tau, Phi, and Sigma/Xi and for comparison with pharmaceutical work in the re-designed state of medication rooms (2018-06-13, 2018-12-03, 2018-12-06). At the point of writing the comparative analyses have not yet been conducted. Pharmacists at the hospital pharmacy have reviewed and ratified the standard (2019-09-11). An evaluation survey was sent to the registered nurse at Care unit Sigma (2019-04-17, 2019-11-18, 2019-11-22, 2019-12-02). Six out of ten nurses responded to the survey, a response rate of 60%. Results are presented below. If the respondents answered that they had worked in the medication room before and after the renovation they were asked to compare with the previous layout, if not they were asked to provide a judgement.

Have you worked in the medication room both before and after the renovation?

Yes	5,	8.,3%
No	1,	16.7%

It is close to the medications and materials I need when I need them.

Much better than before	2,	33.3%
Better than before	1,	16.7%
Worse than before	2,	33.3%
Often close	1,	16.7%

Comments:
Better structure, utilising the small room in a good way. More difficult to get an overview of.

Materials used together to prepare a certain type of medication are placed close to each other.

Much better than before	1,	16.7%
Better than before	2,	33.3%
No difference	1,	16.7%
Worse than before	1,	16.7%
Often close to each other	1,	16.7%

Medications and materials that I need often are closer at hand than the ones I need less often.

Much better than before	1,	16.7%
Better than before	2,	33.3%
No difference	2,	33.3%
Often closer at hand	1,	16.7%

How are the ergonomics when you work in the medication room?

Much better than before	2,	33.3%
No difference	1,	16.7%
Worse than before	2,	33.3%
Bad	1,	16.7%

Comments:
Previously ergonomics were not paid attention to.

How much time does it take to perform all medications for an administration period (with regards to the design of the medication room)?

It takes a lot less time than before	2,	33.3%
It takes less time than before	1,	16.7%
No difference	2,	33.3%
It takes a long time	1,	33.3%

Comments:
A difference to before is also that many medications are delivered as SVD-medications.

I usually adjust the height of the work station.

Agree completely	3,	50.0%
Don't know / No opinion / Neutral	1,	16.7%
Do not agree at all	2,	33.3%

The work surface is large enough to prepare medications (of different types)

Agree completely	1,	16.7%
Agree to a large extent	1,	16.7%
Agree to some degree	3,	50.0%
Do not agree at all	1,	16.7%

To get ordinations and other relevant information from the journal in proximity to where medications are prepared is…

Much better than before	1,	16.7%
Better than before	3,	50.0%
Much worse than before	1,	16.7%
Bad	1,	16.7%

Comments:
Good working height as well.

To sort waste with regards to the placement of waste bins is…

Much better than before	1,	16.7%
Better than before	4,	66.7%
Good	1,	16.7%

The most common medications are placed in the tilted shelves on the work station.

Agree completely	2,	33.3%
Agree to a large extent	1,	16.7%
Don't know / No opinion / Neutral	1,	16.7%
Agree to some degree	2,	33.3%

Comments:
That is, the most common medications at the time.

The most commonly needed materials are placed in the pick-boxes on the work station.

Agree completely	1,	16.7%
Agree to a large extent	2,	33.3%
Don't know / No opinion / Neutral	1,	16.7%
Agree to some degree	2,	33.3%

Materials in the pick-boxes on the work station are accessible with regards to their placement right in front of the work surface.

Agree completely	2,	33.3%
Agree to a large extent	2,	33.3%
Don't know / No opinion / Neutral	1,	16.7%
Agree to some degree	1,	16.7%

Do the extendable tilted shelves in the medication storage make it easy to pick medications?

Much better than before	1,	16.7%
Better than before	2,	33.3%
Worse than before	2,	33.3%
Easy to pick	1,	16.7%

Is the storage for medications sufficient?

Much better than before	2,	33.3%
Better than before	1,	16.7%
Worse than before	2,	33.3%
Sufficient	1,	16.7%

Is storage for other than medications sufficient?

Much better than before	1,	16.7%
Better than before	1,	16.7%
No difference	1,	16.7%
Worse than before	2,	33.3%
Insufficient	1,	16.7%

Is there anything else you think should be known about the furnishings and the design of the medication room?

Comments:
The tilted shelves are often difficult to extend and you have to exert force to unlock them. It is a cramped medication room but appropriate and easy to overview today.

Overall, the changes have received positive feedback from the responding registered nurses. The workstation received positive feedback in terms of medications and materials being used together being placed together, and the more commonly used medications being more easily accessible than those used less often. The work surface was deemed sufficient, information more accessible, waste management improved, and preparing medication is performed quicker. The more negative feedback is in regards to the ergonomics in the room, the tilted shelves for medication storage, and storage of non-medication things. The room remains small which affects work ergonomics negatively despite other changes. With regards to the shelves being tilted, negative responses are difficult to understand as tilted shelves should be more ergonomic than level shelves for picking medications. Further inquiry is required to determine the cause for those responses, but a comment suggests that it could be because the shelves can be difficult to extend. The same goes for storage of non-medication things as the same amount of general storage was provided as before the renovation. With regards to the development of the work station and the placement of furnishings it can be concluded that response was positive and that negative feedback seems to stem from the small size of the medication room.

6.1.6 Summary of Design Science Research Aspects

This section is a brief summary of the design science research aspects outlined in Sections 6.1.2 to 6.1.5.

Field problem and Design problem

- Medication room did not support personnel in medication work.
- Medication work identified as receiving delivered medications, packing up, preparing medication, any temporary storage of prepared medications, preparing transport of medications to patients and ordering medications.

    - Project focused on reducing the time required to prepare medications in the medication room. I.e. not receiving or packing up delivered medications nor ordering medications.
- Medication cart design identified as an issue as they sometimes did not fit in medication rooms resulting in medication preparation being performed outside of medication room.
    - Scope limited to recommendations for altering existing carts.

Object-design

There are several object-designs resulting from the Standard for Medication Work in Care Units project:

- The principles for designing medication rooms.
    - Concentration of materials based on incidence of use.
    - Co-location of medications and materials used together.
- Furnishings in the medication room
    - Work station for injections and infusions.
    - Work station for quick-pick medications.
    - Kit storage for prepared medications.
- Placement and prioritisation of furnishings, which describes in which order to place furnishings and how to place them in relation to other furnishings based on the medication preparation work flow.

Realisation-design

- Establish the medication preparation work flow.
- Establish principles for furnishing.
    - An inflexible solution is impractical due to variation in room layout between care units and which types of medications are prepared at different units.
- Gain management approval.
- Establish a project group.
    - Needs to include individuals with knowledge related to work place design and medication handling and preparation.
- Establish the initiative with the hospital pharmacy and gain their support.
- Align the project with related projects.
- Identify rules and regulations necessary to adhere to.
- Hold a workshop to brainstorm solution suggestions for a standardised model for medication work.
    - Participants to include: Registered nurse(s) responsible for medications at a care unit, expert(s) in workplace design, pharmacist(s), and prescriptionist(s).
- Create an ideal generic layout.

- Establish the first object-designs of solutions.
- Create prototypes of solutions.
- Hold a workshop to test prototypes.
    - Participants to include: Registered nurses and prescriptionists working with medication preparation.
    - Do the solutions work as intended?
    - What adaptations need to be made?
- Adapt object-designs from learnings in the workshop.
- Implement the solutions to test them in a live setting.
    - Perform a work study analysis in the pre-existing layout if possible to create a benchmark (present state). Prepare different types of medications: injection, infusion, pick from box.
    - Adapt to local circumstances
- Evaluate the implemented solutions.
    - Survey the personnel's opinions, e.g. in a survey.
    - Perform a work study analysis with the re-designed layout and compare with the pre-existing work layout. Use the same work sequence to evaluate (prepare the same medications).
- Spread the word and implement at more care units to test the solutions further (and realise improvement)

Process-design

- How the problem was defined and the problem situation diagnosed.
    - See Field problem and Design problem (see Section 6.1.2)
    - With regards to plan of intervention see Object- and Realisation-design (see Sections 6.1.3 and 6.1.4).
        - Object-design includes how the solution design evolved.
    - Workshop 1 entailed exploration and diagnosis of the problem situation.
- How the intervention was applied.
    - See Realisation-design (see Section 6.1.4).
- Evaluation of intervention and object-design.
    - See Object- and Realisation-design (see Sections 6.1.3 and 6.1.4)..
    - Continuously during the progress of the project.
    - Workshop to test solution prototypes (see Section 5.1.2).
    - Decision not to conduct an extensive test and evaluation of medication carts.
    - Present state medication preparation work video recorded at three care units.
    - Implementation and testing of solutions in live setting at care unit.
    - Comparative analysis video recording of improved state (not conducted at time of writing).

- Evaluation survey to registered nurses at care units where solutions have been implemented (see Section 6.1.5).

6.2 Systematic Work Activity Mapping Analysis

This section first presents a summary of Paper 2 followed by a design science research aspects analysis. The section corresponds to Research Question 2: How should work activities in hospital care units be systematically identified, collected, and organised?

6.2.1 Summary of Appended Paper II

The following section is a brief summary of the appended paper concerning the Systematic Work Activity Mapping project: 'Towards the activity based hospital' (Hermansson & Almström, 2018)

Many work tasks are performed all over Sahlgrenska University Hospital, but not in a standardised way. The first step to create standards for activities is to standardise the denomination of the work activities and create a structure to organise them. There are no standards that include work activities that are not strictly patient care. The task is monumental as there are some 650 organisational units at the hospital and potentially all of them have developed their own denominations and way of performing activities. The initiative presented in Paper 2 has managed to bridge the established information structure for the nine participating care units and created the beginnings of a shared work activity structure at Sahlgrenska University Hospital.

Appended paper 2 was framed using the CIMO framework (see Section 2.5). The design science research Aspects section below is a progression of that framing and a more thorough analysis. Appended paper 2 also presents the Systematic Work Activity Mapping method, the Systematic Work Activity Mapping structure, Work activity denomination, and a condensed version of the final work activity mapping list. These are presented more thoroughly in Sections 5.2.1, 5.2.2, 5.2.3, and Appendix II respectively.

6.2.2 Field problem and Design problem

This section describes how the field problem developed throughout the Mapping project. The field problem (the problem situation in reality that could be improved) was rather set at the start of project. Activity mapping had been conducted previously but results had not been reused and instead remained local to where the mapping had been conducted. Different mapping methods had been used. Several reasons for conducting activity mapping were recognised:

- To describe what is planned to be done (e.g. in a shared patient care plan).
- To know that an activity has been performed and to describe how it is performed.

- To describe who does what and when. (Prerequisite to distribution of work and scheduling.)

Additionally, the Swedish Work Environment Authority requires employers to make sure that employees know which work activities they should perform as a first step in ensuring a good psychosocial work environment (AFS 2015:4, §§ 9-10). Establishing a method to identify, collect, and categorise work activities was thus an important endeavour.

The design problem (the problem of solving or improving the field problem) was thus to develop a mapping method and structure for systematic work activity mapping that could be reused to conduct activity mapping with different purposes. The method should be tested at a number of units of different medical specialties in order to ensure applicability and validity regardless of medical specialty. Additionally, alternatives for IT support of the structure was also to be investigated. Early on in the project (2017-10-11) it was clarified that support functions such as Finance and HR was delimited from.

6.2.3 Object-design

This section describes how the object-design developed throughout the Mapping project. The object-design (the design of the intervention or of the artefact) of the structure and the mapping method was subject to a number of criteria from the outset:

- The structure shall be systematic and support different purposes for conducting activity mapping.
- The structure shall be implemented in a database.
- The method shall be efficient to use and it should not take more than 1-2 hours per unit for the unit manager and a few personnel to map all work activities at the unit together with a method expert facilitating.
- The same method shall be able to be used at different types of units and medical specialties.
- Work activities shall be formulated so that they can be used across units and medical specialties (where applicable).
    - Consideration shall be made between this generalisability and the need of exact description of activities.

At the project start-up meeting (2017-10-11) the question was raised if work activities should be organised in in 'packages', e.g. 'surgical care unit' consisting of base package 'care unit' with addition 'surgical'. This was decided against as such packaging was deemed unnecessary. Units could better describe their work activities by simply going through a list of work activities activity by activity instead and get a detailed account of conducted work activities. It was also decided that the Swedish work environment regulations AFS 2015:4 would be used as a guide.

A first draft of a work activity list was created after the project start-up meeting. The denomination of work activities was mixed between both verb form and noun form. The list was structured hierarchically with three levels: 1. Type of work, 2. Work activity category, 3. Work activity. The structure of the work activity list was deemed to be non-intuitive (2017-12-20). If a work activity was direct or indirect patient work was not important to the personnel that carried out the work. The level Type of work was removed and the new top level became Work activity category (2018-01-16). The hierarchical organisation was kept. The three most basic levels of the activity structure was established based on MTM-SAM, and the need of a bridging level 3 Work activity variant was identified. Section 5.2.2 goes into detail on the final Systematic Work Activity Structure. The denomination of work activities was also decided to be according to verb form and not noun form (2018-01-16). Additionally, they should be denominated as close to the personnel's everyday language as possible without compromising specificity. Section 5.2.3 goes into detail on the final Work Activity Denomination. The first non-draft version of the work activity list was completed 2018-01-31 by having reworked the draft according to these decisions.

Which work activities to focus on was decided 2018-03-05 to be delimited to the work activities by the personnel employed at the care units. I.e. to not include work activities carried out at a care unit by personnel employed elsewhere, e.g. by consulting physicians or physiotherapists, as these work activities were deemed to be performed at those units instead. Version 2 of the work activity list was created 2018-03-19 after visits to care units Alpha, Beta, and Gamma. Version 3 was created 2018-04-11 after visiting care unit Delta.

To identify suitable software for data input and data handling as well as to specify functionality for the Work Activity Structure Database was decided instead of actually establishing such a database (2018-05-02). This was due to obstacles with the IT department and a deviation from one of the initial criteria for the object-design that specified that the structure should be implemented in a database. The specification of database structure and data handling for a Work Activity Structure Database was thus formulated (2018-06-04).

Version 4 of the work activity list was created 2018-04-25 after visits to care units Epsilon, Zeta, Eta, and Theta. The final version (see Appendix I), Version 5, was created 2018-05-09 after the visit to unit Iota, the last care unit visit. The care unit visits rendered 188 comments on work activities which led to no new Level 1 Work activity categories, 30 new Level 2 Work activities (32 new of which two were later merged with other work activities), and 18 denomination changes. The first version of the work activity list had 19 Level 1 Work activity categories and 102 Level 2 Work activities, the final activity list has 19 Level 1 Work activity categories and 132 Level 2 Work activities.

The five most commented Level 1 Work activity categories: 1. Treat (22), 2. Assist patient (21), 3. Wait, and handle disruption (17), 4. Clean (15), and 5. Examine (14). These were the categories where the personnel had the most to say. Possibly either because they are particularly large categories or noteworthy for some reason, e.g. problem areas.

The five Level 1 Work activity categories with the highest number of new Level 2 Work activities in relation to number of commented work activities: 1. Examine (6 new, 14 comments; 0.43), 2. Handle personnel issues (4 new, 13 comments; 0.31), 3. Talk with patient (4 new, 10 comments; 0.30), 4. Handle information not concerning a specific patient (2 new, 8 comments; 0.25), and 5. Communicate about a patient (2 new, 9 comments; 0.22). These were the categories where the contribution from the personnel to expanding the categories were the greatest. This could indicate that these categories can be expanded also in the future.

The five Level 1 Work activity categories with the lowest number of new Level 2 Work activities in relation to number of commented work activities: 1. Handle materials and equipment (0 new, 9 comments), 2. Plan patient care (0 new, 6 comments), 3. Report (0 new, 6 comments), 4. Do the rounds (0 new, 3 comments), and 5. Wait, and handle disruption (1 new, 17 comments). These are categories that generate a lot of interest but not any new work activities. This could indicate that these categories take up a lot of focus in the minds of the personnel.

6.2.4 Realisation-design

This section describes how the realisation-design (the plan for the implementation of the intervention or constructing of the artefact) developed throughout the Mapping project. Much of the realisation-design for constructing the work activity structure and the mapping method was set based on the criteria for the object-design (see the previous section). Several units of different medical specialties would have to be involved. In the project start-up meeting (2017-10-11) it was decided that data should be collected in focus group interviews at care units with specific personnel from these units. That entailed that visits had to be booked and not be impromptu visits as well as not be long-winded and take up too much of their valuable time. It was also decided that the members of the project group should collect the data in different constellations and not unaccompanied. It was also decided that a work activity list would serve as the focus for the focus group interviews.

In order to delimit the project it needed to be determined how many different types of units there were at Sahlgrenska University Hospital (2017-11-14). A list of units at the hospital was created and they were identified and categorised them on medical specialty. A first categorisation of care units was made according to Paediatrics, Medicine, Surgery, Psychiatry, and Combined care (e.g. emergency care). It was decided that the project should focus on the care units that would provide the most (useful) information for the hospital (2017-12-06). I.e. focus on inpatient care (being uniquely hospital care) and to focus on the Medicine and Surgery specialties since they constitute the two largest categories of care units. About five units of each category was deemed an appropriate number of units to visit.

A communication plan was established (2017-12-20). It was deemed important to be clear on the work effort required to participating care units. Additionally, a clearly formulated vision for the project would make communication easier with care units when asking them to participate. The two main points that were communicated were to adhere to the Swedish

work environment regulation AFS 2015:4 and to prepare for the upcoming implementation of a new electronic health record platform. Apart from unit managers and personnel union representatives at the hospital were identified as key stakeholders to inform of the project. The project manager informed representatives at a hospital management and union representative coordination meeting.

A work activity list draft was created as a starting point for the development of the work activity structure object design. This draft was made into the first version of the work activity list after it had been reworked according to reflections on the work activity structure and work activity denominations (2018-01-31). After the first care unit visits had been booked (2018-02-14) it was decided that the work activity list should be updated on the next project group meeting following a care unit visit. Ideally this would result in saturation of collected comments and data on work activities. A key takeaway from the first care unit visits was that it is important that the care units present work activities that are specific to them and they know intimately, i.e. not other work activities or work activities in general (2018-03-19). Comments that did not lead to the addition of a new work activity to the list or a denomination change were kept as commentary to the pertaining Level 2 Work activity if they exemplified related prospective Level 3 Work activity variants.

Initially it was planned that the database should be implemented in a database. The establishing of a database was also initiated with the regional IT department (2017-10-11). However, it was determined 2018-05-02 that actually getting it established would take a long time as the IT department was seemingly reluctant. Instead the project focused on establishing specifications for such a database (2018-06-04). At the conclusion of the hospital project it was decided that any project continuation of further mapping of activities of other types of units or at more detailed levels (Work Activity Structure Levels 3-6) was to wait for the regional project implementing a new health information system.

6.2.5 Process-design

This section describes how the process-design (the plan for the Problem Solving Cycle and the method used to design the solution to the problem) developed throughout the Mapping project. To recap the Problem Solving Cycle see page 23.

How the problem is defined and the problem situation was diagnosed is outlined in the Field problem and Design problem section above. Additionally, one of the main points of agreement at the project start-up meeting (2017-10-11) was that all questions and answers did not need to be identified from the outset. Instead these would develop as the project progressed. The description of alternative solution designs and selection of solution is outlined in the Object-design section above. How the intervention was applied is described in the Realisation-design section above. The intervention was mainly evaluated continuously during the progression of the project, such evaluation is described in the Object-design and Realisation-design sections above.

6.2.6 Summary of Design Science Research Aspects

This section is a brief summary of the design science research aspects outlined in Sections 6.2.2 to 6.2.5.

Field problem and Design problem

- Results from previous activity mappings had not been reused.
- Necessary to establish a method to identify, collect, and categorise work activities to:
    - Describe what is planned to be done.
    - Know that an activity has been performed and describe how it is performed.
    - Describe who does what and when.
- Method and structure needs to be systematic and reusable for different purposes.

Object-design

- Systematic Work Activity Mapping method
- Systematic Work Activity structure
- Work Activity denomination
- Specification of Requirements for Work Activity Mapping Data Structure and Data Management
- Work activity list of Level 1 and Level 2 work activities at care units.

Realisation-design

The following is a summary of a how to carry out an initial systematic work activity mapping:

- Establish a draft work activity structure (either form scratch or based on previous projects)
- Establish a work activity list draft if possible (based on previous projects)
- Determine work activity categories (e.g. generic, specific, and levels of hierarchy)
- Determine work activity denomination.
- Delimit the mapping to some types of units.
- Collect data through focus group interviews
- Gather comments on work activities from those interviews.
- Review work activity structure
- Review work activity list based on comments from focus group interviews.
- Review should be performed by a group of specialists in the work activity structure, denomination, and work activity list to ensure quality of entries and considerations regarding specificity and simplicity.
- Establish a final list of work activities after a suitable number of interviews and signs of saturation of new comments for fine-tuning the list.

Process-design

- How the problem was diagnosed
  - See Field problem and Design problem (see Section 6.2.2).
- Alternative solution designs and selection of solution
  - Outlined in Object-design (see Section 6.2.3).
- How the intervention was applied
  - Described in Realisation-design (see Section 6.2.4)
- How the intervention was evaluated
  - Continuously throughout the project.
  - Described in Object-design and Realisation-design (see Sections 6.2.3 and 6.2.4).

6.3 Designing for Resource Efficiency at Hospital Care Units

This section analyses and discusses the results of the Standard for Medication Work in Care Units and Systematic Work Activity Mapping projects from the perspective of Resource efficiency and increased productivity. The section corresponds to Research Question 3: How can resource efficiency for manual work activities in hospital care units be systematically improved? The section also includes analysis of creation of local standards and 'Standardisation sliding', stakeholder dynamics, and inter-organisational and intra-organisational communication.

6.3.1 Resource Efficiency and Increased Productivity

Resource efficiency is often discussed in terms of capacity utilisation or resource utilisation (see Section 2.1). However, a resource can perform work more or less effectively regardless of utilisation. A resource could perform work inefficiently and be 100% utilised in terms of capacity, which would still be considered high resource efficiency (no unutilised capacity). Therefore it is poignant to distinguish between resource efficiency and resource utilisation. High resource efficiency is when work performed by a resource is performed according to a well-designed work method and a normal pace as determined by a pre-determined time system, e.g. MTM-SAM. Low resource efficiency is then if work is performed at a slower pace or according to a work method that takes longer time to perform compared to a well-designed (standardised) work method.

By improving the resource efficiency of work activities productivity can be increased without increased resource requirements or work-related stress as a consequence of having to work faster. To exemplify: a resource, e.g. a registered nurse, performs a number of activities A_x and to perform these activities takes time t_x (Figure 23). For the purpose of this example activities A_x are identical.

Figure 23. A resource performs a number of activities A_x in time t_x.

Due to a required or desired increase in productivity, e.g. as a result of increased demand, activities A_x need to be completed in a shorter time t_y than before (Figure 24).

Figure 24. Due to new requirements activities A_x need to be performed in time t_y.

If no adaptation is made, some activities (greyed out) then end up in a backlog or queue, or risk being left undone (Figure 25). In this case the required productivity increase is not met.

Figure 25. Without adaptation some work activities will not be performed in time.

One solution is to add resources in order to offload the existing resource (Figure 26). The same work can then be performed in line with the new required time t_y.

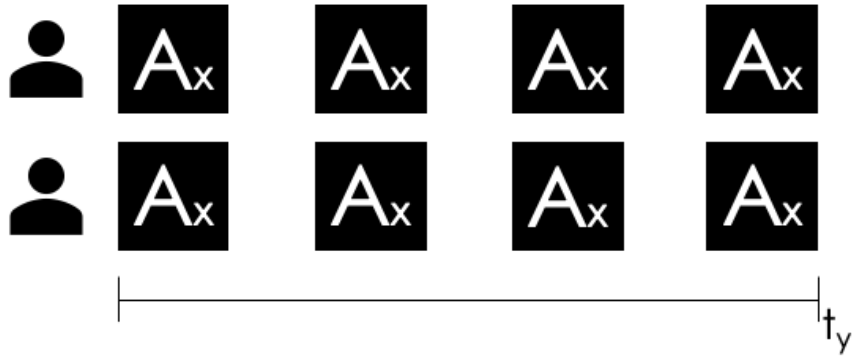

Figure 26. A resource is added to manage to perform activities A_x in time t_y.

However, this solution increases the cost of performing the activities and requires available resources. Adding resources to perform work activities is difficult as there is a shortage of personnel in Swedish healthcare (see Section 1). Another solution is to make the existing resource perform activities A_x in new time t_y without any adaptations (Figure 27).

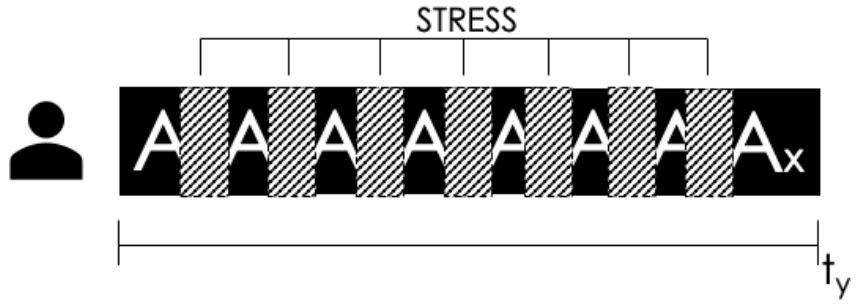

Figure 27. Performing work activities A_x in time t_y without adaptation creates work-related stress for the resource.

Such a solution creates work-related stress for the resource performing the work activities. Since time to perform activities would be insufficient by design the resource would have to work at above normal pace to complete all activities or cut corners in performing them risking lower quality as a result. The solution advocated for in this licentiate thesis is to review the work method and improve it (see Section 2.3.1). By using work study analysis the work method for work activity A_x can be improved. A_x can be replaced with improved work activity A_y with a well-designed work method and the work activities A_y can ideally be performed in new required time t_y(Figure 28).

Figure 28. By improving work activities A_x, reducing the time required to perform them, improved work activities A_y can be performed in time t_y.

In all three solutions work activities can be performed in compliance with the new time required to fulfil the required or desired productivity increase, but with different consequences. The first solution involves increased resources, the second increased work-related stress and risk of lower quality, and the third involves a concerted effort to improve work activities. Which solution that is chosen can differ between units and departments depending on the decisions of different unit and department managers. Within the same department units can choose different solutions to meet a common requirement for increased productivity. Regardless of if those units are in sequence or parallelised in terms of the patient pathway method-related variation of resource efficiency in performance of work activities risks contributing to longer length of stay, higher resource requirements, work-related stress, or unequal care. Patients at care units where work activities are not performed according to well-designed work methods would risk receiving less care in the same time-period compared to patients at units where work activities are performed according to well-designed work methods. Alternatively, patients would risk being admitted for longer in order to receive the same care. Care units where work activities are performed according to well-designed work methods could also require less resources to perform the same work compared to care units where work activities are not performed according to well-designed work methods. The latter would then need more resources in order to get the same work done in the same time. Alternatively, the personnel would risk having to work faster in order to provide the same care in the same time, contributing to work-related stress and a sense of not having enough time to perform work activities.

For improvements in resource efficiency of work activities to result in increased productivity the following steps are necessary:

1. Systematic Work Activity Mapping
    a. Which work activities are there?
2. Work sampling study
    a. Determine how much time is taken up by different work activities in order to prioritise which ones to improve first.
3. Work method improvement
    a. Describe an initial method or standard method in order to identify key steps and create a benchmark for improvement.

b. Improve the method by establishing the best current way of performing it and if necessary re-design the physical environment in order to realise a more efficient work method.

4. Realise the improvement
    a. An improved work method will either a) lessen the pressure from work stress if the situation is such that work is performed at a higher than normal work rate or is left undone or b) free up time or capacity for other work activities. In order for an improved work method for a work activity to contribute to higher productivity the freed-up time or capacity must be allocated to other activities or spent on performing more of the same activity.

Step 1 has been addressed in the Systematic Work Activity Mapping project. Step 2 was addressed by the pre-study work sampling study (see Section 4.1.1). Steps 3 and 4 have been addressed in the Standard for Medication Work in Care Units project. Systematic Work Activity Mapping is required in order to be able to improve work activities systematically, i.e. throughout the whole system or organisation. Before work activities can be systematically improved they need to be collected and organised so that it is clear which activities there are, which activities are the same but are known by different terms, and distinguish between variations on similar activities. The delimitation of Systematic Work Activity Mapping is the unit level, i.e. which work activities are performed at the unit. Who performs the work activity is only required when allocating different resources, e.g. registered nurses or physicians, to perform activities and not necessary when describing them. Systematic Work Activity Mapping is done to organise activities in a structure and establish standard work methods for them, i.e. descriptions of how to perform work activities. Establishing a standard work method of performing a work activity is also necessary for improving that method in more than one instance. Work methods can be explicit, implicit, ad hoc, or standardised. Without a standard method it is not possible to determine if a change in a work method will lead to an improved work method. If work activities are not collected or organised any work activities that are improved would only be improved locally. If work methods are established locally, i.e. at the unit, group, or individual level, there is a risk that there will be a method-related variation in efficiency due to sub-optimisation or establishing a work method that is not as well-designed as it could be.

6.3.2 Creation of Local Standards and 'Standardisation Sliding'

Standards as they exist presently are in the form of routines and guidelines established at different levels: legal, national, regional, hospital, department, or unit (see Section 5.1). Routines are commonly created at the department or care unit level to adapt them to local circumstances. This practice makes it difficult to provide standards that are aimed to change local circumstances. Additionally, procedures for carrying out work often do not describe how to carry out complete work activities and instead focuses on how to perform certain elements or focuses on characteristics of the result, e.g. quality, safety, and medical integrity.

Such characteristics are of course important and should not be disregarded, but are seldom described in relation to each other or how to perform work efficiently.

With regards to standards and standardisation it is common in healthcare to 'slide' from 'High' to 'Low' for both standardisation related to product design characteristics and standardisation related to process choice (see Section 2.4). Either because a patient's condition is considered as, or is managed as, more unique than it really is or that the healthcare organisation relies on the healthcare staff's skills and experience to substitute for appropriately standardised operating procedures. I.e. Low variation in product design characteristics treated as High variation and relying on healthcare staff's skills and experience to moderate a scarcely standardised process to approximate a standardised process. Sliding in terms of level of standardisation is from High-High (Low variation in product design characteristics and highly standardised processes) to Low-High (Products with high variation of design characteristics and highly standardised processes) or High-Low (Low variation in product design characteristics and scarcely standardised processes), and from Low-High or High-Low to Low-Low (High variation in product design characteristics and scarcely standardised processes). Relying on staff's skills and experience as substitute for standardisation puts undue (cognitive) stress on personnel who have to continuously make decisions and considerations to manage their daily work. It also makes the organisation reliant on more qualified personnel than what could be the case if operating procedures were standardised.)

6.3.3 Stakeholder Dynamics

There were several examples of different stakeholders having either relinquished interest in addressing problems within their sphere of influence or exercised their authority to the detriment of addressing problems. This was particularly apparent in the Standard for Medication Work in Care Units project. The Region Västra Götaland hospital pharmacy clearly delimited itself from intervening with how work areas were designed in hospital's medication rooms. This placed the issue to be solved within the domain of the hospital. To provide well-designed work areas for medication rooms then was the responsibility of the individual care units and the care unit managers. Thus, the chance of a cohesive solution was reduced due to the decentralised point of design decisions. The facilities planners at the hospital could be such a cohesive force, perhaps also for other types of work areas. However, the role of the facilities planner is to guide the process of constructing or renovating facilities. The decision power remained with the care unit managers. In the case of the Medication Work at Care Units project none of care units Rho, Pi, or Omicron wanted to furnish their medication rooms based on the standard in the renovation of their care units. The reasons were that they were not interested in furnishing the room based on the standard and that they would rather plan their medication rooms themselves. Thus the risk for creating work areas that are not well-designed from a work efficiency perspective is apparent and variation in how efficiently work can be performed will be high.

6.3.4 Inter-Organisational and Intra-Organisational Communication

There were also several examples of poor communication between different actors, particularly in the Standard for Medication Work in Care Units project. With regards to the renovation of the medication room at care unit Sigma, the hospital facilities planner did not initiate any discussion between the care unit and Västfastigheter's renovation project manager despite the quoted cost exceeding the budget by 100%. The renovation project manager in turn did not negotiate the quoted price of the work station with the supplier despite it being their responsibility according to the hospital procurement strategist. Important information was also communicated with short notice. The date for starting the renovation was announced to the care unit by the renovation contractor with four days' notice and was not relayed to the author as development manager by either the contractor, the facilities planner, the renovation project manager, or the care unit manager. Similarly the final inspection was announced with two days' notice resulting in the author not able to attend and rushing to do a solo inspection the day prior and the care unit manager cancelling a day's planned leave to attend.

With regards to communication regarding potential medication rooms at care units to include in the project there were different examples of communication issues. Despite the need of renovating the medication room being identified, a former colleague reaching out to the author for help, and the author reaching out to the care unit manager of Care unit Nu the manager did not reply. At Care unit Mu it was realised that medication room furnishings had already been decided on and ordered despite the facilities planner and care unit manager requesting help to design the room. In the case of Care unit Lambda the Facilities planner that had been informed several times about the project group looking for medication rooms to include in the project did not inform the project group, and such information reached the project too late as furnishings had already been decided on.

7 DISCUSSION

In this section the author discusses and reflects on being both an industrial doctoral student and an insider in the studied organisation, the similarity between realisation- and process-designs, as well as the generalisability of the results.

7.1 The Researcher as Insider in the Studied Organisation

As development manager at Sahlgrenska University Hospital the author has had a rare access to the empirical setting unattainable for many researchers. Being naturalised to the setting this access has provided the author with both opportunities to observe and to act from within the setting where the research was conducted. Such proximity contributed to being able to build relations with colleagues at the hospital: nurses, unit managers, prescriptionists and others, leading to good and open discussions. It also contributed to nuance and detail in data collection and analysis, which would have been difficult for a non-immersed researcher. E.g. in descriptions of different work activities, how to prepare different types of medications, or identifying stakeholder dynamics. As an actor driving change, reactions to change were able to be collected first-hand. There are also challenges being an insider in the studied organisation. To start with, the risk of lacking an overview perspective due to such proximity. This risk has been countered by maintaining a strong presence at Chalmers University of Technology. The research has also been discussed with peers in the academic community. Throughout the years the research has been discussed with fellow doctoral students and senior researchers e.g. at courses and yearly Ph.D. workshops (2016-2019). The research has also been presented several times at different conferences: 2016 Swedish Production Symposium, Lund; 2017 EurOMA, Edinburgh; 2018 EurOMA, Budapest; 2018 NOVO Symposium, Helsinki; and 2019 NOVO Symposium, Copenhagen.

7.2 Similarity Between Realisation- and Process-designs

In relation to design science research, the solutions are made up of three types of designs: object-design, realisation-design, and process-design (see Section 2.5). However, there is a similarity between the realisation-design and the process-design of the solutions for both the Standard for Medication Work in Care Units and the Systematic Activity Mapping projects. The realisation-designs describe the plan for the implementations of the interventions or construction of the artefacts, and the process-designs describe the method used to design the solutions to the problems. As both projects involved designing a solution in an organisational context, implementation (or at the least adaptation to the existing organisation of work and responsibilities) became part of the solutions. The similarity between the realisation- and process-designs also draws on the similarity between the problem solving cycle and the basic way to performing methods engineering (see Table 16).

Table 16. Comparison between the problem solving cycle and the basic procedure of Methods engineering.

The problem solving cycle (see Section 2.5)	Methods engineering basic procedure (see Section 2.2)
1. Define the problem out of its 'messy' context	i) Analyse the present work situation
2. Plan the intervention	
a) Diagnosis of the problem situation	ii) Identify problems
b) Design of alternative solutions	iii) Produce improvement ideas
c) Selection of solution	iv) Select the best idea
3. Apply the intervention	v) Implement and standardise new methods
	vi) Ensure adoption of the new methods.
4. Evaluate the intervention	vii) Evaluate the impact of the new methods

The problem solving cycle and the basic procedure for methods engineering are virtually identical apart from step iv and the emphasis of standardisation in step v in the latter. Otherwise the only difference is in the choice of words. As both projects have used the problem solving cycle as a basis to construct artefacts (e.g. the Systematic Work Activity Mapping method and kit storage), drawing upon the tradition of methods engineering, realisation-designs and process-designs have become similar.

7.3 Generalisability of Results

In terms of generalisability, the research is analytically generalisable. Analytical generalisation is generalisation to theoretical propositions and not to populations as in statistical generalisation (Yin, 2014; p. 21). It can be likened to how experiments are conceived and conducted: Are results as expected and in line or deviating from the hypothesis and existing theories? In terms of validity, the generic designs in the two projects are well-tested, well-understood, and well-documented to establish pragmatic validity: that the interventions result in the intended outcomes. The research conducted in this licentiate thesis corroborates the theoretical concepts used to conduct the research. In relation to methods engineering, the results of the studies are consistent with the classical definition of methods engineering (see Section 2.2). Methods engineering includes analysis of work systems. In the Systematic Work Activity Mapping project a method for identifying, describing, and organising the contents of the hospital care units work system is created. The contents of the work system are the work activities performed at the care units. In the Standard for Medication Work in

Care Units project the medication preparation work has been subjected to close analysis to eliminate unnecessary elements to approach the quickest and best method of performing each necessary element of the work. The project strived to improve and standardise the equipment and work area as a proxy for improving and standardising the work method. The method factor of productivity is based on how work is designed to be performed in the ideal case (see Section 2.3.1). The work area and equipment for medication preparation work was addressed directly instead of the work method because performance of the medication preparation work activity is heavily dependent on the design of the work area. Additionally, training of personnel is decentralised to the different units making it difficult to train all registered nurses and prescriptionists at the hospital in new work methods. Performance would then still be primarily decided by the design of the medication rooms. Thus the equipment and work area was addressed to guide the performance of medication work and improve work methods indirectly.

The context in which the research was conducted is typical for public hospitals in Sweden with regards to how Sahlgrenska University Hospital is organised based on the medical specialities and how personnel conduct their work (see Section 3.3). What distinguishes Sahlgrenska University Hospital is its size in terms of number of units and employees. An area manager corresponds to a hospital CEO of a smaller hospital due to the size of the areas. At other hospitals there are no area managers and department managers answer directly to the hospital CEO. If organised in medical themes based on patients' pathways instead of medical specialties theme managers corresponding to department managers answer directly to the hospital CEO. Regardless of how a hospital is organised many work activities are shared across organisational boundaries. If organised as department or theme is inconsequential for e.g. medication work, which is conducted at other departments or in other themes. The same holds true for e.g. food handling, cleaning, and storage handling. Work activities are thus in need of being improved in a systematic manner to ensure that (standardised) improvements are realised throughout an organisation, regardless of where they are performed.

Furthermore, the research in this licentiate thesis has concerned hospital care units but results may be useful in a wider context as well. What distinguishes work activities at hospital care units are that there is a certain level of medical complexity connected to the activities as patients are admitted to the care units. However, many work activities performed at a hospital have corresponding similar work activities performed at e.g. primary health care centres and retirement homes. It is not a stretch to imagine that these work activities are also shared across care centre departments or retirement home units in a municipality or other organisation. Conceptually, there is nothing implying that the results of this licentiate thesis could not be applied in those settings as well. This means that results are not limited to hospital care units but can be applicable to (Swedish) healthcare in general.

8 CONCLUSIONS

This licentiate thesis is focused on systematically mapping work activities and how to improve resource efficiency for work activities. Systematic Work Activity Mapping is concerned with the former and Standard for Medication Work in Care Units is an example of the latter. The overall aim of the research conducted for the thesis was to analyse how resource efficiency for manual work activities can be improved in order to also improve productivity and work environment at hospital care units was met by answering three research questions:

1. How should medication work at a hospital care unit be improved to become more efficient?
2. How should work activities in hospital care units be systematically identified, collected, and organised?
3. How can resource efficiency for manual work activities in hospital care units be systematically improved?

The Standard for Medication Work in Care Units project demonstrated how resource efficiency can be improved for manual work activities by answering Research Question 1. A solution consisting of several object-designs, a realisation-design, and a process-design has been presented. The object-designs (see Section 6.1.3) include:

- Principles for designing the medication room (see Section 5.1.4):
    - Concentration of materials based on incidence of use, and
    - Co-location of medications and materials used together.
- Furnishings in the medication room (see Section 5.1.5), particularly focusing on
    - Work station for injections and infusions and work station for quick-pick medications, and
    - Kit storage for prepared medications.
- Placement and prioritisation of furnishings

The realisation-design (see Section 6.1.4) describes the plan for how to implement the Standard for Medication Work in Care Units intervention and construct the object-designs, whereas the process-design (see Section 6.1.5) describes the method used to design the solution. As shown in Paper 1 (Hermansson & Almström, 2016) , the potential to improve individual work activities was outstanding.. By redesigning the workplace and work method for preparing medication in one care unit, the potential productivity increase was determined to be 287.1%.

The Systematic Work Activity Mapping project demonstrated how to systematically identify, collect, and organise work activities and, in turn, answered Research Question 2. This is necessary in order for improvements in resource efficiency to be applied in all instances in which improved work activities are performed. If work activities are not systematically

identified, collected, and organised, then improvements in resource efficiency remain localised, and system productivity will not improve. As an antidote, a solution consisting of several object-designs, a realisation-design, and a process-design has been presented. The object-designs (see Section 6.2.3) include:

- Systematic Work Activity Mapping Method for identifying and collecting work activities (see Section 5.2.1),
- Systematic Work Activity Structure for organising work activities (see Section 5.2.2),
- Work Activity Denomination terminology for describing work activities (see Section 5.2.3),
- Specification of Requirements for Work Activity Mapping Data Structure and Data Management (see Section 5.2.4), and
- A work activity list (see Appendix I).

The activity structure comprises six levels: 1) Work activity categories, 2) Work activities, 3) Work activity variants, 4) Building blocks, 5) Sequences, and 6) Elements. Levels 4-6 are generic and can be used to construct or describe Activities and Activity variants, whereas Levels 1-3 are specific and discrete and do not appear in other work activity categories, work activities, or work activity variants respectively. The terminology for items at all levels was based on conveying action or activity. Descriptions for items thus follow the form of [Verb] + [Subject], e.g. a Level 1 item 'Treat patient' or a Level 2 item 'Prepare medications'. Each Level 3 item description is a continuation of the Level 2 item under which they are a variant, e.g. the instruction 'Prepare medication from pill in cartridge to package in cup' comes from 'Prepare medication' (Level 2) 'From pill in cartridge to package in cup' (Level 3). The results of a mapping performed at nine different types of care units have also been presented. In mapping, 19 Level 1 items (i.e. Work activity categories) and 132 Level 2 items (i.e. Work activities) were identified, collected and organised in the final work activity list version. The corresponding realisation-design (see Section 6.2.4) describes the plan for how to implement the Systematic Work Activity Mapping intervention and construct the object-designs, while the corresponding process-design (see Section 6.2.5) describes the method used to design the solution.

Section 6.3, 'Designing for Resource Efficiency in Swedish Healthcare' answers Research Question 3. By drawing upon both research projects and tying together Research Questions 1 and 2, that section provides a higher-order answer mirroring the aim of the licentiate thesis. The causal relationship between resource efficiency, increased productivity, and work environment has also been described (see Section 6.3.1). The necessary steps for improvements in the resource efficiency of work activities to result in increased productivity have also been outlined, as follows:

1. Systematic Work Activity Mapping
2. Work sampling study
3. Work method improvement
4. Realise the improvement

Additionally, three themes impacting the improvement of resource efficiency in the two projects are described: Creation of local standards and 'standardisation sliding' (see Section 6.3.2), Stakeholder dynamics (see Section 6.3.3), and Inter-organisational and intra-organisational communication (see Section 6.3.4).

Altogether, it has been demonstrated that resource efficiency can be improved for manual work activities to also improve productivity and work environment in hospital care units and how to identify, collect, and organise work activities.

8.1 Implications for Theory and Practice

The research in this licentiate thesis has several implications for both theory and practice. As for theory, it underscores that resource efficiency views the way in which resources are used differently from what is commonly the case concerning resource utilisation. In short, resource utilisation does not consider how activities are performed (Sundkvist, 2014; p. 85). By contrast, *resource efficiency*, as defined in this thesis, refers to how efficiently activities are performed by resources to produce output. Furthermore, the research addresses problems related to production engineering in a healthcare context. Methods engineering has been used to address these problems and add to the field of healthcare production engineering. It has been illustrated that productivity can be improved by starting with improving the resource efficiency of the work activities that make up a flow instead of starting with improving flow efficiency. Commonly in productivity improvement, e.g. through lean initiatives, the first steps are to establish the process, identify bottlenecks, and determine flow efficiency. Beginning with trying to improve flow efficiency leads to focusing on resource utilisation, as bottlenecks are made up of localised restricted capacity. Increasing productivity through improving flow efficiency is then done by increasing capacity of the bottlenecks by adding resources to better match the capacity of other parts of the process. At best the work performed by the resource is improved locally in the specific flow. Importantly as this licentiate thesis concludes, if the point of departure is to improve resource efficiency, improved resource efficiency contributes to flow efficiency by increasing the capacity of existing resources across flows. It does not require identification or establishment of flows, only identification of instances where the work activities are performed. For design science research, the thesis has added to the body of research of design science in healthcare, answering van Aken's (2004) call for Design science management research to address utilisation problems of academic management research. This has been done by providing rich descriptions of how to solve problems of designing work areas for more resource

efficient manual work activities and systematic mapping of work activities have been provided. Similarities between realisation-design and process-design when combining design science research with Methods engineering have been identified, indicating a shared similar approach.

Regarding implications for practice, the thesis provides knowledge for how to improve resource efficiency in work activities at hospital care units. For healthcare management groups, regional healthcare boards and other actors having an interest in and influence on the productivity of healthcare systems the results are of particular interest. The thesis describes how to establish a systematic work activity structure and identify, collect, and organise work activities to describe the contents of a work system consisting of work activities that make up work flows. Establishing such a structure enables systematic improvement of work activities in contrast to local improvements at specific units or in specific flows. This in turn enables productivity improvement throughout the work system. Also of interest is how to improve resource efficiency in work activities generally. Not only to healthcare boards and management groups but also to department managers, care unit managers, or hospital business developers wanting to improve work activities locally. For the latter group how to improve resource efficiency for medication work specifically is described. It is also described how resource efficiency can be improved through design of the work area and equipment rather than addressing the design of work methods directly.

8.2 Future Research

Stemming from this thesis, the paths for future research are numerous. An obvious future research path is to establish not only potential productivity increase, but its realisation, and across numerous different care units, for medication work and for other work activities. Conducing comparative studies of before and after improving resource efficiency, e.g. in continued implementation of the Standard for Medication Work in Care Units project, would provide research on resource efficiency change over time. The work environment aspect can also be expanded. E.g. by conducting rapid entire body assessment (REBA) and rapid upper limb assessment (RULA) postural analyses comparing work performed in a pre-existing work area and to work performed in an improved work area. Improving resource efficiency could also be investigated with a greater scope, e.g. a complete care unit or department, to study the direct impact on productivity.

Future research related to Systematic Work Activity Mapping could be to complement the mapping method with more explicit division of activities into subgroups. E.g. there are plenty of activities that are common for all care units, some that are only common for surgical care units, and some that are unique for specific units. This would result in collections of activities that are common for different types of units and collections of activities that are specific to e.g. a medical specialty, sub-specialty, or unit. It could also be part of future research to apply

Systematic Work Activity Mapping and test the method and activity structure at other types of units than care units, as well as at more care units. Further work could also go into establishing clearer definitions of the activity levels of the activity structure. Particularly levels 1-3 Work activity category, Work activity, and Work activity variant.

From a design science perspective future research could be to propose a generalised design for workplace improvement. This would concern conditions for performing work activities with improved resource efficiency in general, rather than for medication preparation specifically. Further development into such a generalised design proposition could be to adapt it to designing work areas where multiple work activities are performed in the same area. Ideally the work method for all those work activities would be improved, but resource efficiency should definitely be improved in the aggregate if not for each separate work activity. Perhaps the improvement of the work area to foster improved work methods could be based on a prioritisation or ranking of multiple work activities according to criticality, rate of occurrence, and duration.

The research in this licentiate thesis has been conducted in the domain of production engineering. One avenue for further research regards inclusion of the management aspect, thereby broadening the scope to the field of industrial engineering (Figure 29).

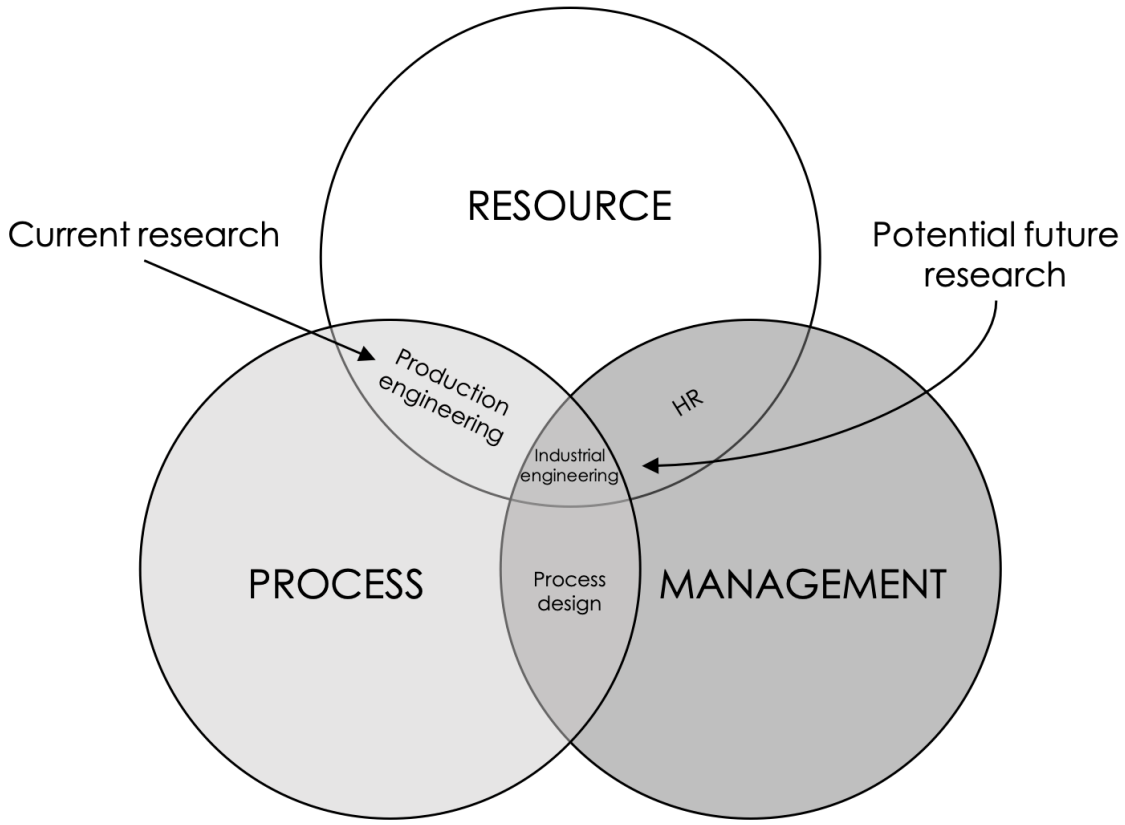

Figure 29. Venn diagram of Process, Resource, and Management and their intersections: Production Engineering, Industrial Engineering, and Human Resources.

The thesis has focused on investigating resources and processes (through study of work activities) while the management aspect has been contextual rather than a focus of analysis. As described in Sections 6.3.2, 6.3.3, and 6.3.4 the organisation and management affects the implementation of work activity resource efficiency interventions. A broader scope may reveal new aspects and solutions to the productivity problems in Swedish healthcare.

It would also be interesting to do further research into standards and standardisation with regards to work methods. 'Standardisation sliding' was described in Section 6.3.2 based on Berger's (1997) model for types of standards for operator work process as a function of product design characteristics and process choice (see Section 2.4). 'Sliding' occurs either because a patient's condition is considered as, or is managed as, more unique than it really is or because the healthcare organisation relies on the healthcare staff's skills and experience to substitute for appropriately standardised operating procedures. However, in healthcare the level of standardisation of product design characteristics (patient diagnosis and results from treatments) is seldom a choice. Connecting the lack of choice in level of standardisation of product design characteristics to actual process choice and compare it to appropriate process choice would be interesting to investigate if the problem of 'standardisation sliding' can be developed further. Additionally, it would be interesting to relate standardisation of work, product design characteristics, and process choice to different types of work—for example, between knowledge work and manual work (sliding scale), between pre-determined and emergent work activities, or between serial production and handicraft work activities.

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